THE PURSUIT OF EXCELLENCE

History, Knowledge, Sustainability

"It is our fondest desire that this project
will be good for the people of Montalcino,
good for Italy, good for America,
good for all people who love fine wine."

John F. Mariani, 12 September 1984,

dedicating the Banfi winery in Montalcino.

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The Mariani family, the Board of Directors of Banfi
and its Chairmen, thank:

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Contents

Preface 11

1. Natural and genetic resources 13
1.1 The climate 13
1.2 The soils, landscapes of Banfi and the new expansion areas 15
TABLE 1 - Brunella: a very special whale 17
The new areas of expansion 18
1.3 The vines and the contribution of research 18
Past research projects and application consequences 19
The 2016-2024 research project: Banfi 3.0 20

2. Evolution of production technology in the vineyard 24
2.1 Types of vine training 25
TABLE 2.1 - Sustainable vineyard management 27
TABLE 2.2 - Banfi Alberello training form 28
2.2 Rational management of soil and water, for optimum nutrition of the vines 30
Agronomic soil characterization 30
The analysis of petioles for vineyards in production 31
Water as a balancing factor of production 31
Evolution of nutrition and micro-irrigation in relation to the new objectives of viticulture 34
TABLE 2.3 – The variable rate micro-irrigation: an experience created at Banfi 36
2.3 Plant control and protection 36
TABLE 2.4 – The BIO-BED for treating washing water of agricultural equipment 38
2.4 The mechanical harvest 39
TABLE 2.5 – Photobiology in the vineyard to determine the phenolic ripening of the grapes 43

3. Enhancement of the grape: from vineyard to winery, new goals and new technologies 45
3.1 The size of the berry: a marker of the enological potential of the grape 45
The trial investigation 51
The results 52
Conclusions 60

3.2 Enhancement of red grapes, cleaning and sorting techniques 61
The selection systems at Banfi 62
Manual sorting on belt, Selective Process Winery and Selective Process Vision - Pellenc 64
Tribaie - Amos Densimetric Sorter 65
Delta R2 Vistalys - Bucher Vaslin Optical Sorter 66
3.3 The HORIZON fermentor 68
Technological benefits obtained with the Horizon fermentor 70
Further notes 71
Specific benefits of the wooden body 74
Function of the lower steel tank 74
Results 76
General considerations 79

4. Corporate sustainability 82
4.1 The reduction of the Carbon Footprint 82
4.2 Erosion control 83
4.3 Water consumption 83
4.4 Waste management 84
4.5 Biodiversity 84
TABLE 4.1 – The wildlife-hunting preserve 85
4.6 Environmental protection 86
TABLE 4.2 – Contribution to the variety of the landscape: the estate's other crops 86
4.7 The enhancement and development of the territory 90
TABLE 4.3 – Tourism and food service 90
4.8 Human resources 94
4.9 Certifications and participation in Consortiums for brand protection 94

Looking ahead to the FUTURE 95

Preface

The Pursuit of Excellence is the passionate chronicle of the journey that started 40 years ago to discover our region and its incredible potential. A journey rich in experiences, challenges, achievements and extraordinary as well as lasting successes. However, Research is also evidence of the continuing and undeniable desire to improve the knowledge and the fruit of our daily work, conducted with humility, curiosity and passion that have always animated our thinking and our philosophy.

Our desire for knowledge, never tamed, was and still is moved by a feeling of genuine love for research, experimentation, and knowledge, in all areas of our business. Nourished and fed, in some ways even obliged, by an awareness to live and manage a worldwide unique production company in the world: vast, complex, and with potential still partially unexplored, and to be explored and developed further.

With its 3000 hectare area, a third of which are dedicated to vineyards and grape varieties typical of the whole Tuscan landscape, with 29 different soil and climate profiles and a clonal wealth unmatched in the national wine scene, our Montalcino estate is in fact, a unique example, a constant challenge to research and stimulate the improvement of technology and agronomic knowledge, without compromise and without saving energy and resources.

We accepted this challenge 40 years ago, aware that we could make the most of a unique territory and its main grape variety, Sangiovese, only with rigorous and continuous research, combined with the experience gradually gained. A procedure that we like to express as the concept of "dynamic development".

A commitment to research and continuous improvement, which is the authentic expression of our history, filled with respect for the most genuine tradition, but also interpreting and driving change, innovation and cultural enrichment.

The challenge has drawn lifeblood from our thirst for knowledge, a true mission and inspiration for all development projects, for research and experimentation at times empirical and creative, but always extensive and shared.

A challenge, finally, that has always referenced the future and in future generations, with the desire to leave behind a better human and cultural heritage than what we found in 1978, when it all began. Design Sustainability, to use a

current trendy term that has always been our style.
Ten years ago, aware that the dissemination of knowledge was the decisive aspect of our research, one that more than any other would make our actions strategic and essential, we decided to tell our story, the results of our research and our dynamic development, publishing a scientific volume of about 500 pages, indeed, The Pursuit of Excellence, still recognized as one of the most rigorous, comprehensive and ambitious treatise on these issues ever made privately. Issues such as zoning and clonal selection, the pride of our research team, and until then relegated only to academics and a small circle of scholars, they became the prerogative, thanks to the strictly scientific, but never dull, lay language that was immediately understandable to a wider circle of enthusiasts and wine lovers.
Today, ten years after this ambitious publishing project, along with an updated edition that has now been enriched with new experiences and new scientific discoveries, some of which are discussed and revealed as a preview in this volume, we have decided to double our energy and publish this light version. Certainly more lively and more usable, but no less profound and comprehensive.
Thus, a Pursuit of Excellence for all, that tells the story of the uniqueness of our territory, our tireless passion and, above all, our innate desire to write, with the usual curiosity and humility, a new page on the fascinating world of wine.

1

Natural and genetic resources

The overview at Banfi can only start from the environmental resources: climate, soil and grape varieties, which help to define the great potential of this Estate. Through the work of many, this potential has been channeled in a productive process that has interpreted tradition and technological innovation as two powerful engines that synergistically drive the Company towards the pursuit of excellence.

1.1 Il clima

The climate is a very important variable in growing grapes. In fact, it significantly affects the yield and quality of the product. Since it is an essential component of the suitability of the environment, it is necessary to thoroughly understand the relationships between the various climate factors and production characteristics.
Banfi has five monitoring stations, located in the areas of: Marchigiana, Cardeta, Centro Frutta, Sorrena and Banditone (Fig. 1.1). The parameters, which are measured daily, are: minimum and maximum air temperatures, rainfall and evapotranspiration, sunshine duration, wind, leaf wetness, air and soil

Fig 1.1 - Map of climate monitoring stations

humidity. The indications obtained may be used as technical support for both the management of the current year and for the planning of future vineyards. The detection locations identify the main productive distribution areas of the Estate: Marchigiana, the hill area of the initial expansion (late 70s - mid-80s); and Cardeta, Centro Frutta, Sorrena, which consist of the vineyards established in the following two decades. Currently the Company is implementing a new expansion policy in the hill area, which is re-evaluating the area of Marchigiana as a source of biodiversity.
In general, the entire area is characterized by the high sun exposure index and high ventilation. These factors, jointly with the thermopluviometric course, contribute to determine a remarkable degree of health of the foliage, but also an actual evapotranspiration from the crop-soil system of 5-8 mm day-1 in the period from May to August, regardless of the area concerned. Over the years, the rainfall has become more erratic, with fewer, but very intense rainfall. To this, must be added a marked variability in the overall rainfall, which falls between less than 500 to over 1000 mm/year. All this has required more attention in water management to both regulate the excess and for emergency irrigation interventions.
On comprehensive analysis (Fig 1.2), the environment is characterized as warm-temperate, with an average temperature of 19.5° C during the April-September period. The average of weather reports show minimum temperatures below 5° C from December to March, but rarely below zero, and values between 10° and 18° C from May to September. The maximum temperatures fall within the range of 10-15° C in the period from November to March, while from May they exceed 25°C, with peaks of 35-37°C in August. The temperature range (i.e. the difference between daytime highs and nighttime lows), so important for the proper ripening of the grapes and the color of musts, is 17°C

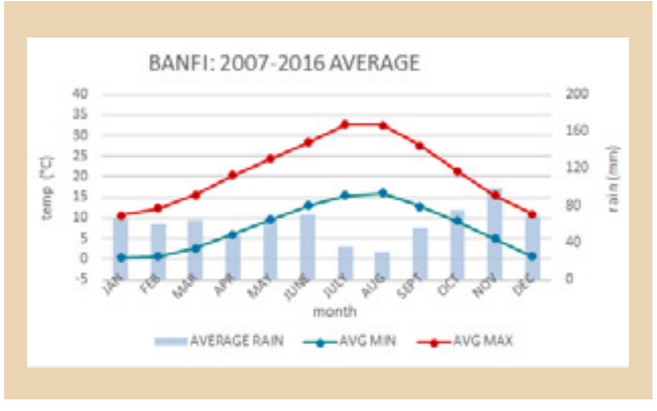


Fig. 1.2 - Average decade trend of temperatures and precipitations

in July-August and 15°C in September, with peaks up to 19° C in the summer of 2012.

1.2 The soils, landscapes of Banfi and the new expansion areas

The landscape of the Banfi territory has strong complexity with very different soils, ranging from 80-100 and 330 m above sea level (Fig. 1.3).
The soils are extremely different, both in origin and mineralogical composition, making the Estate, from this point of view, a real set of very different production units, alternating with large natural wooded areas or areas cultivated in an environmentally sustainable manner. At lower altitudes, soils formed by fluvial and alluvial elements predominate; at the higher altitudes, marine sediments are found, consisting of sand and calcareous sand, often with abundant sub-rounded pebbles and altered by atmospheric agents, alternating with clay and clay-sandy soils, typical of a deep sea sedimentation environment. Within this framework, the discovery that occurred in 2007 is not surprising. Along the road leading to the Castle of Poggio alle Mura, the complete skeleton of a Pliocene whale fossil was discovered that proved the past presence of intense marine life (Table 1.1).

Proceeding from the morphological bottom to the top of the Estate territory, Banfi's vineyard areas can be grouped into four distinct environments, or landscapes:
1) A from flat to slightly sloping environment: characterized by geological forms of mainly fluvial origin, with river terraces and connecting surfaces between terraces and the alluvial valley floor. Locations: Madonnino, Casaccia, Cardeta and Belcontento; have morphologically higher inland fluvial terraces than inland. The soils appear deep, with preserved pedogenesis layers and well developed.
2) Predominantly hill environment: moderate slope hills, characterized by straight or slightly convex sides; locations of Tavernelle, Pascena, Amorosa, Podernuovo, Leccini and Castello; have moderately deep, but well developed soils, with an abundant skeleton (stones and pebbles), sometimes with outcrops of low-fertile sandy sediments.
3) Hill areas: characterized by terraces and gentle slopes, locations of Santa Costanza, Marchigiana, Poderuccio and Lambertone; have more unfertile, clay soils that are moderately deep to shallow, with less skeleton, and the presence of blue-gray clay lenses and sandy layers.
4) Modified hill environments: Poggioni, Collorgiali, Marrucheto, Fontaccia,

TABLE 1 - Brunella: a very special whale

Thanks to the collaboration between the Archaeology, Fine Arts and Landscape Superintendency for the provinces of Siena, Grosseto and Arezzo, the Institute of Archaeo-Anthropological Studies (ISA) and Banfi, almost ten years after the discovery, in November 2016, a workshop was carried out for the restoration of BRUNELLA, the Pliocene whale fossil found with its complete skeleton in 2007 at Castello Banfi, Montalcino (SI), presumably dating back 4-5 million years ago. The excavation and restoration were performed in an innovative manner of the paleobiological school, in its first edition, aimed at university students, researchers and scholars, which provided an opportunity for high-level training in skills and direct application of different techniques of excavation, study and restoration of paleobiological specimens. The project, which obtained recognition by the Italian Association for the Study of the Quaternary, relied on the support of the Municipality of Montalcino and the valuable contribution of scholars from various institutions (Physical Earth Sciences and Environment Department at the University of Siena, Department of Earth Sciences of the University of Pisa, GAMPS of Scandicci, ISA-Institute of Archaeo-Anthropological Studies, Visual Arts Laboratory of the Scuola Normale Superiore of Pisa, Museum of Natural History at the University of Florence, San Diego Natural History Museum, Archaeological, the Fine Arts and Landscape Superintendence for the provinces of Siena, Grosseto and Arezzo). The area of the finding is just one of many areas of Banfi that shows the presence of an intense marine life in distant geological eras: shells and fossils of all kinds are in fact frequent finds in the course of geo-soil surveys and normal agricultural activities.

< Fig 1.3 Anti-erosion ditch

Sorrena, Cerretalto; soils have changed by past cultivation interventions; there is often an abundant skeleton with evident surface erosion in the higher slope areas. The soils are moderately deep to shallow.

The new areas of expansion

During the last decade, the Winery experienced a growing interest in wines increasingly characterized with regard to the variability of Banfi micro-territories. In relation to this, the Company moved to the geo-pedological exploration of potentially new viable vineyard areas, identifying for this purpose land previously discarded, because considered technically "difficult." These are soils with obvious limitations in terms of texture and composition, planted, up to that time, with grassland legumes and cereals, grown in accordance with the dictates of organic agriculture. The areas of interest are predominantly the hills of S. Costanza, Poderuccio, Marchigiana, Collorgiali and Poggioni. More than half of these soils were found to be deficient in organic matter and biological fertility, with structure limits that result in plants with difficult rooting. It is noted, however, that the presence of the soils' skeleton is, in this case, a positive factor for the improvement of internal drainage. In addition, today's available innovations at an agronomic technical level allow to exploit these rugged landscapes, modulating the extent of their environmental stress in order to elevate grape quality.

1.3 The vines and the contribution of research

At the beginning of Banfi project, and roughly until the mid-80s, much of the planted area was dedicated to the Moscadello and international white vine varieties, Chardonnay and Sauvignon Blanc, having the foresight to also grow Pinot Grigio. Among the red varieties, in addition to Sangiovese, Cabernet Sauvignon, Merlot, Syrah and Pinot Noir were also introduced. The rootstocks were the most varied, also to meet the availability of nurseries in the face of intense initial planting programs. The most used was the 1103P, for its adaptability to heterogeneous and often saline soils; only after discovering its negative features, which can be summarized by the production of basal shoots and the excessive vegetative growth /vigorous recovery, 1103P, was excluded in new plantings.
In subsequent years, Sangiovese has become the predominant grape variety. It now covers over 50% of the Banfi's vineyards in Montalcino. After 2010, however, a new phase of variety renewal started, which also considered planting of small vineyards of Cabernet Franc, Petit Verdot and Vermentino, an activity that is still ongoing.

Past research projects and application consequences

Since 1982, Banfi has pursued the clonal selection project with the subsequent approval of 11 specific clones of Sangiovese, able to fit in polyclonal vineyards, suited to different pedology-climate conditions and winemaking needs (Fig. 1.4). Through integrated research in the vineyard and in the winery, we found that some respond well in particularly hot viticultural areas, where the need is felt to maintain acidic musts; others are good accumulators of sugar, and therefore particularly valuable in vintage years less favorable to maturation; others, finally, provide longevity and aromatic complexity to wines for aging.
Brunello Poggio alle Mura is the most representative result of these activities,

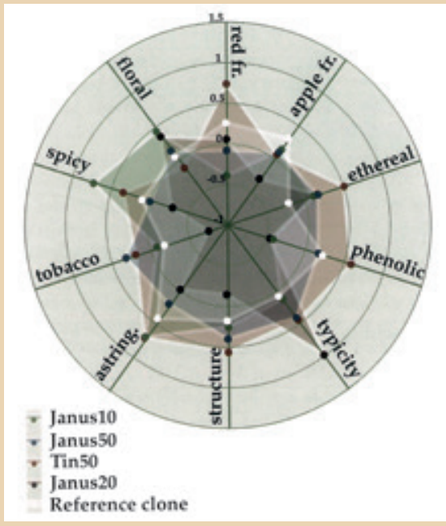


Fig. 1.4 Comparison of the aromatic profile of 4 Sangiovese clones, which make the blend, and the reference clone

which later ended up affecting all Sangiovese-based red wines made by the estate.
The estate zoning, which began in the '80s, of Sangiovese, Cabernet Sauvignon and Merlot grown in the most representative estate territories, made it possible to discover the Genotype x Environment interaction, in view of its agronomic, physiological and enological, to optimize the insertion of the different grape varieties in the Banfi landscapes. During the course of this activity,

Vocation Units were established that were found to be uniform for vegetative, production and quality performance, in order to enhance the typical features of each grape variety according to the major micro-environments, in relation to specific production purposes. This work laid the foundation for the enhancement of the potential of micro-territories, anticipating the vision of Banfi to be attentive to the specificities of its "Vocation" unit landscapes.

The 2016-2024 research project: Banfi 3.0

As part of the Banfi 3.0 project, the estate is rapidly moving towards a restructuring of production aimed at a reduction of agrochemicals for greater environmental protection and consumer and employees health. The experimental vineyards planted at the beginning of 2017 meet the need for agronomic management with particularly low environmental impact, thanks to the introduction of new genotypes or varieties obtained from interspecific of varietal crossings, which have demonstrated high quality standards and/or features of reduced sensitivity to major fungal diseases, some of which are considered true resistant varieties. Such "varietals" stem partly from the research and development of the Edmund Mach Foundation of San Michele all'Adige and partly from the synergy between the University of Udine and the Rauscedo Cooperative Nurseries. These eco-sustainable varieties are gaining interest, so much so that some Italian Regions have authorized trials for a full assessment of their characteristics at a plant pathology, agronomy and enological level. Within this framework, the trial just started will also be useful for the inclusion of these new varieties in the list of varieties suitable for cultivation in the region of Tuscany.
For this purpose, two experimental vineyards were planted in the winter of 2016-2017 under the scientific responsibility of the Research Unit for Viticulture of the CREA-VIC of Arezzo: one in a hill area (Marchigiana) and one on a plain (Cardeta), to evaluate different operating conditions for soil and climate factors. In the first case, the test involves 22 experimental varietals, compared with Vermentino and Sangiovese; in the second case, 16 experimental grape varieties, having, as comparison, Sangiovese and Sauvignon Blanc. The material, on rootstock SO4, was chosen based on its promising agronomic characteristics: small berry, small size and low compactness of the bunches, low sensitivity to rot and fungal diseases, regularity of ripeness, low fertility of the buds. Of these, 18 originate from crossings selected for promising enological characteristics and/or the specific resistance to fungal diseases. Of the 22 experimental grape varieties, 16 are red, 5 white, and 1 gray. The planting density is 5,500 (hill) and 4,800 (plain) vines per hectare, at equal spacing (2.60 m). The training system is spurred cordon.
The size of the trial will allow for diversification of defense strategies, according to the soil and climate characteristics and the vine varietals and so as to define a "Banfi Protocol" having the objective of reducing significantly both per hectare dosages and the number of agrochemical treatments[1]. The agronomic, phytopathological, analytical and organoleptic controls will continue throughout the farming phase and for at least the next three vintage years of production, with reference to plants, grapes and wines, for the various aspects. In fact, the "size" of the trial is such to allow, in perspective, meso vinifications representative of the enological potential of individual vine varietals.

[1] The agrochemicals are all technical means characterized by specific chemical formulas that are used for the protection of crops both for the prevention of animal (mainly insects) and plant

2

Evolution of production technology in the vineyard

The focus on sustainability inspired Banfi from the initial years of its history. At the beginning, sustainability was mostly directed to production aspects, aiming at optimizing the use of technical tools and human resources. Later, it was included into an ever more harmonious environment of production activity. The individual aspects, such as training systems, management of soil and water, nutrition, and protection of vines, were connected together in a synergistic way. Thus, the Company can respond dynamically to the quality objectives in a balanced relationship with the environment.

2.1 Training systems

In Montalcino, vines have always been trained on a traditional spurred cordon. In the '70s, this form suffered from obvious technical limitations with regard to the squaring of the rows, choice of poles and quality of iron wire. It was then that Banfi, with an eye to the future, chose move to the "Casarsa", to rationalize mechanization and because it produced/guaranteed the desired quality. On permanent cordon, branches were pruned to 3-4 shoots, and 6-8 buds. The vegetation was left unbound, part of it attached to the two overhanging wires while the grape producing branches, under the grape weight, bowed and thus, dynamically controlled the natural acrotony of the vine. At the end

of 1984, the estate operated 500 ha with "Casarsa" and about 200 ha with spurred cordon. In subsequent years, for Sangiovese, Banfi started the first thinning of both shoots and bunches, to improve the quality of the grapes used in the production of Brunello. In 1992, mechanical pruning with manual finishing was introduced in the Casarsa-trained. This method, on some varieties with fertile basal buds, combined with short pruning, raised the quality of the obtained grapes.
At the turn of the 1990-2000 decade, dense planting (7142 vines per hectare) was also tested, which, upon further examination, was later discarded. The grapes produced were of good quality, but not excellent. Moreover, in vintage years with weather conditions that were not optimal, it was more difficult to obtain healthy grapes from the densely planted vineyards with low cordons close to the ground, compared to those planted with average density (4000-5000 vines per hectare) and slightly higher cordons. With foresight, at the time, the Company devoted less energy to pursuing current trends and more to reducing the chemical impact, pursuing a path to simplify operations that, at the time, was not yet called "sustainability".
After 2000, the need to have more high-quality red grapes led to replanting programs. The choice for training high-quality red varietals was initially the unilateral spurred cordon, with distances 3.0 x 0.80 m (4166 vines per hectare), which allowed to perform various manual operations (thinning of shoots and bunches) without bending over. For white grape varieties, where grape ripening must be slow and thinning is not foreseen, the free cordon training system was chosen, aiming at lower productions, respecting quality.
From 2010, Banfi started a new stage of production by increasing plant density of some 1,000 plants per hectare, thus bringing them to 5,000-5,500, with the aim of improving the production quality of each single vine.
However, there was a continued need to overcome some agronomic problems for red varieties, including the premature aging of the spurred cordon and the increased incidence of esca disease a result of the cuts. Through subsequent attempts, in 2002, finally, a new original training form was reached, suitable for difficult soils and growing conditions with low input and able to meet the needs of a viticulture based on new sustainable management criteria (TABLE 2.1): the Banfi alberello training form (TABLE 2.2).

Table 2.1 - Sustainable vineyard management

New management criteria consist of a very focused technical approach to real environmental sustainability values aiming, above all, to the entire production chain. The goal that Banfi sought to achieve is to never abuse methods of crop defense, and instead, only use them after having ascertained their actual need. In fact, it is important to "prevent" the onset of diseases, particularly the cryptogrammic diseases. The topic is complex, ranging from the choice of soil, the varietals, the training system, fertilization, etc. To achieve this goal it is essential to monitor vineyards every week, especially starting from the fruit set phase. Therefore, scouting measures are implemented, also with the aid of modern photo-biological techniques, to follow the leaf canopy evolution, seizing the first attack symptoms of the various pathogens. All this in order to lead the crop defense treatments according to the logic of timely intervening only when strictly necessary, and always with target-oriented products, dosages and application methods.

Table 2.2 - Banfi Alberello training form

This training system, established in 2002, made it possible to optimize the management and the quality of red varietals, responding fully to the needs of sustainability of current and future viticulture. In fact, it allows to exploit the marginal areas, allows a marked reduction in the use of technical means (water, fertilizers, agrochemicals) and requires a lower number of working hours per hectare, because the vine is not subject to thinning of shoots and rarely of bunches. Furthermore, the plant reaches a high degree of balance between vegetation/production earlier, establishing an extensive photosynthesizing wall also permeable to air movements. Thus, grape ripening and higher bunch health is encouraged, as bunches are always well exposed, all with a logic of maximum sustainability.
A further advantage is the possibility that the alberello training form can be used in perfect synergy with the spurred cordon, allowing the use of two different training forms within the same vineyard, and even within the same row. This allows to choose the best form to compensate for the variability of the soil within the vineyard, so that the single plant can express all its potential and, consequently, achieve a quality level of excellence in the wines.
With time, further positive aspects were found. In particular, the lower incidence of diseases of the wood, a good consistency of production even in less favorable vintage years, and, above all, the high quality of grapes from being produced on the older branches.
Obviously, the Banfi alberello training form is not suitable for fertile land and rootstocks, which induce vigor nor for varieties with small bunches and low fertility. Therefore, primarily for Sangiovese in Montalcino, it is the training system on which the estate intends to focus to meet the new objectives of quality and sustainability of production.

2.2 **Rational management of soil and water, for optimum nutrition of the vines**

Agronomic soil characterization

Nutrition is a critical aspect of the quality course of the vines, because it deeply affects the production process and maturation of the grapes. After an initial characterization of the land through soil surveys, the areas identified for new vineyards are further tested for physical and chemical characters of the 0-40 cm layer and, from this point on, follow a "course of agronomic improvement" which may involve various years and various stages, before actual planting the vines. In short, unlike the majority of the vineyard estates, which have no choice of when to plant a given area because of the constraint of the modest size of the company, Banfi can allow each soil to achieve the optimal agronomic fertility conditions without forcing natural cycles. One detail is enough to illustrate this philosophy of sustainability: the second crop of the estate with regard to extension, after the vines, are organically grown legume meadows, a natural source of fertility due to the fixation cycle of atmospheric nitrogen of the rhizobia. The presence of these meadows, in rotation to the old varieties of long straw hard wheat and emmer wheat, increases soil organic matter content and improves soil structure, thus promoting the bioavailability of many macro and micronutrient elements (nitrogen, phosphorus, sulfur, iron, boron, etc.). In addition, it helps reduce the so-called soil seed bank, namely the extent of weed seeds in the topsoil, to lessen their harmful presence in the new vineyards. All this enables the production of grapes under conditions of perfect compliance with environmental sustainability.

The analysis of petioles for vineyards in production

The physical-chemical analysis of soil, however, is just one of the diagnostic tools available to the technical staff that organizes plant nutrition. The level of fertility thus identified is, in fact, only a given potential that, in practice, may be more or less affected by the combination of negative factors: difficulty of the root system growth, adverse weather conditions, etc. Hence, the analysis of the petiole of the basal leaf node, as opposed to a bunch, carried out at the beginning of fruit set, allows for determining the actual nutritional status of plants for all macro and micro elements. At Banfi, at least 25% of the vineyards are annually controlled by this method. The choice of the vineyards to analyze is carried out in two stages: a first set is identified during the review meeting for harvest results, based on the production quantity and quality, commenting also the vigor of the plants; a second set is instead identified in the spring, according to the initial results of the winery and the performance of vegetative restart. At the level of individual vineyards, trend curves of the nutrients allow to detect in advance the progress of the overall nutritional status of the plants and then, along with the yields and the quality characteristics, these analyses form the basis for deciding any corrections in previously determined fertilization, as well as the use of additional specific treatments to be performed in a timely manner.

Water as a balancing factor of production

In Montalcino, during the summer, there are often major water shortages, which coincide with the beginning of veraison, decisive for the ripening process. When this occurs, the synthesis of polyphenols is blocked or slowed down, while the vine, not having sufficient water for thermoregulation (linked to the transpiration of the aerial part), is damaged by burns on leaves and bunches. Water, then, if well dosed, becomes an important quality assurance factor. For this purpose, since 1986, the estate has had the objective of implementing supplemental irrigation in a more sustainable way, namely, using micro-irrigation; such technique, to date, is used on over 50% of the vineyards. One specifically considered aspect was that of the development of the control systems for water stress, both at soil (various types of probes) and plant level (stomatal chambers, and, more recently, thermal images) in order to intervene in a very precise manner.
To support the growing water requirements and limit the recourse of drawing water from the rivers Orcia and Ombrone, over the years, Banfi has gradually increased the availability of artificial reservoirs ("lakes" or "basins"), located to

service the most important production areas (Table 2.1). The individual rainwater collection units are inter connected with underground pipes, so as to allow to move the water where this resource is most needed. Also, when possible, they are located in a high position, to irrigate the vineyards "by gravity", that is, without the use of pumps, thus reducing the consumption of energy. The water in the lakes is generally rainwater, collected in fall and winter. Only in some very dry years was it necessary to supplement the contribution of rainfall by drawing from the rivers, at the beginning of spring. In this case, it is necessary to carefully consider water quality, if only to remove water with the minimum presence of suspended solids, in order to preserve the filters of the micro irrigation systems.

RESERVOIRS	CONSISTENCY (m³)
Castello Lake	100.000
1-2-3 Lake	270.000
Collorgiali Lake	120.000
Cardeta Lake	57.000
Casina delle Rose Basin	97.000
Perella Basin	12.000
S. Ersilia Basin	3.200
Collupino Basin	3.300
TOTAL	**662.500**

Tab. 2.1
Artificial Reservoirs and their consistency at the end of 2016 at Banfi[2].

[2] With "*lake*" we mean a reservoir that is placed deep into the ground; while the term "*basin*" indicates a pool placed above ground, supported by artificial embankments.

Evolution of nutrition and micro-irrigation in relation to the new objectives of viticulture

The attention to the specificity of micro-territories of the Banfi landscape, even with saline and low agricultural fertility soils, has certainly been able to proceed and be implemented thanks to new acquisitions in terms of grape varieties, rootstocks, training forms and technical systems, without forgetting the contributions of mechanization and water regulation, including drainage. As part of soil management, the following ongoing trials deserve mention: (i) on the new amendments, e.g. "char" type originating from the wood cycle, which perform a role in carbon storage in the soil contributing, as much as possible, to the mitigation of climate change, and (ii) on correctives with a starter effect, applied as micro granulated or water dispersible formulations, made of plant based extracts of vine and sweet chestnut, to stimulate the rooting of vines at various stages of development and, above all, after their planting.
However, the main acquisition includes variable rate micro-irrigation, which Banfi has used for the first time on vines since 2008 (TABLE 2.3).

Table 2.3 - The variable rate micro-irrigation: an experience created at Banfi

The slope and variability of soils, both with regard to texture and skeleton content, as well as the depth of the actual layer that is explorable by the roots, very often, makes it extremely difficult to manage micro-irrigation in viticulture: there is, in fact, the risk that some plants receive too much water or too little, depending on whether they are in the most favored areas, perhaps at the bottom of a slope, or in the more rocky, higher areas. Under these conditions, consequently, the supply of water can even increase the dissimilarity in the vineyard, with negative effects on the quality of productions, as well as on the life span of the plantings.
To overcome these problems at Banfi, since 2010, oversized micro-irrigation systems have been designed, with drip pipes with a diameter of 20 mm and a flow rate 1 l/h, which is normally enough to manage the plants during the first two years. Then, during the 2nd-3rd year, once the growth of the vines along each row has been assessed, the lateral may be doubled in the area where the resulting growth is unsatisfactory, inserting drip pipes with a flow rate 0.9 l/h on a second branch, parallel to the first, and connected to the previous one with a T-joint. Based on many years of experience, the seemingly simpler alternative, to double or triple the capacity by adding additional emitters to the drip pipes in less favored areas was dismissed due to their low resistance to the mechanical harvesting phase. Consequently, by careful management of water, and possibly added fertilizer, this variable rate concept allows to uniform the vineyard.

2.3 Plant control and protection

One of Banfi's priorities has always been obtaining a natural product through sound management of environmental resources. The weekly phytopathological monitoring service integrates the detection of climate data through the microclimate control units with the use of pheromone traps, to control the development of the phytophagous insect populations. In doing so, it is possible to determine the best intervention time for the efficiency of the active ingredients used. Since 2016, the estate has nevertheless undertaken a new road towards the development of a Banfi Production Protocol, with the aim of reducing agrochemicals, thanks to the convergence of the start of the trials on

resistant varieties and the adoption of new training forms.
In order to preserve biodiversity and reduce erosion, Banfi implements controlled green cover the vineyards in production, usually in alternating rows. The rows without green cover are instead tilled with special equipment (disc harrows and flexible tine harrows, hoes, etc.). Generally, manual hoeing is implemented near the vines, where the machines, even if equipped with feeler systems, are not able to intervene with the quality required by the estate. Possible localized chemical interventions are limited to the control of certain difficult and very invasive weeds, but even in this case, innovative solutions are being researched that exclude the use of agrochemicals.

Table 2.4 - The BIO-BED for treating washing water of agricultural equipment

With the goal of reducing the point pollution derived from plant protection treatments, in 2008, a system was created for washing agricultural equipment, called BIO-BED. The project, created in collaboration with the Department of Agronomy and Agroecosystem Management of the University of Pisa, eliminates environmental dispersion of oily residues originating from agricultural treatments that remain in the washing water. After each chemical treatment tractors and sprayers are washed in specific places, in which the washing water is collected and channeled to an "organic bed". This bed is formed by a mixture of straw and manure, in which colonies of bacteria develop that decompose the oily residues and the active ingredients of the various agrochemicals used in the vineyard. The Bio-Bed wastewater, suitably conveyed into a collection sump, is periodically analyzed and, according to the test results, the bed is regenerated with new organic material to keep the bacteria colonies always at the maximum level of efficiency. The project, including the related results, was presented to the industry and the press, at Castello Banfi in 2010. During the last three years, 172,000 to 195,000 liters of washing water were treated, with a total abetment of accidental leaks of oily residues and agrochemicals.

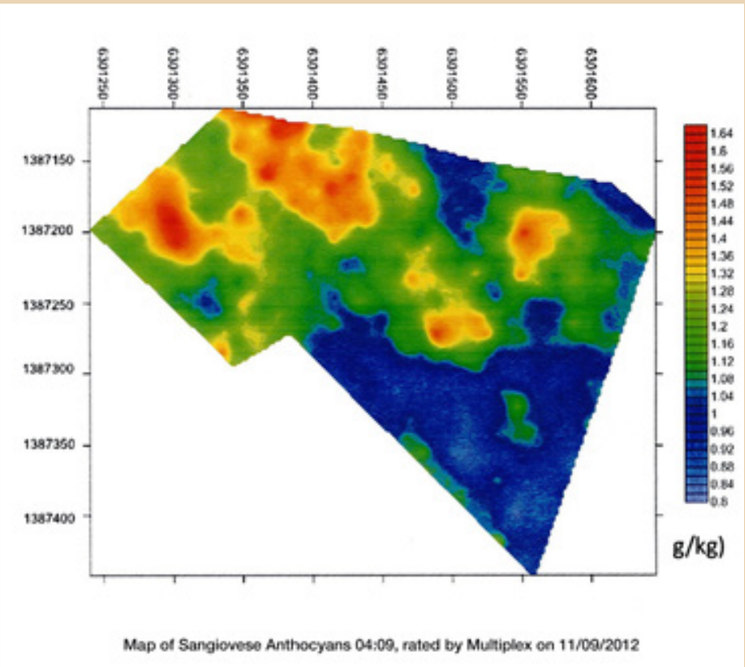
2.4 The mechanical harvest

Research has highlighted the importance of intervening in the winery on grapes harvested at relatively low temperature, as found in the early hours of the morning. In order to limit the practice of refrigeration, which is an area of low environmental sustainability due to the use of energy-intensive facilities, Banfi has systematically addressed the issue of mechanical harvesting since 1993, also because of the difficulty in finding labor during the narrow time frame of 40-50 days. The introduction of mechanical harvesting has required a series of changes and adjustments both of the vineyard structures (poles and wires) and the organization of transport and crushing sites. The assessed quality ad-

vantages are undeniable and all positive. Through mechanical harvesting it is, in fact, possible to:
- Intervene in accordance with the optimal timeliness, once the ideal harvesting time through grape sampling and monitoring of the ripening curves is identified.
- Harvest grapes at lower temperatures and send the product to the winery faster, reducing the time between harvest and the beginning of vinification. With the harvest that starts as of mid-August, during a period that is generally very warm, it becomes easier for the machines to harvest at dawn or at night, when grapes are cool, and stop in the late morning. In early varieties such as Pinot Grigio, Chardonnay, Sauvignon, and Vermentino, quality levels are obtained that were unknown before the use of the grape harvesters.
- Operate very promptly to avert damage to grapes in vintage years with few "windows" of good and dry weather.
From an organizational standpoint, we operate with about 25 people and 7-8 harvesters, in addition to a technician who manages the work sites, including transport of the grapes to the winery. Mechanical harvesting has contributed to enhancing the estate's micro-territory and, together with the selection of post-harvest treatments (which will be dealt with the winery section), has enhanced the quality of the wine.

Table 2.5 - Photobiology in the vineyard to determine the phenolic ripening of the grapes

Optical methods for the evaluation of the degree of phenolic maturation of the grapes are considered to be of great interest as they are non-destructive, repeatable over time, inexpensive, quick and applicable to a large number of samples. The plant tissues have different fluorescent molecules. When a leaf is excited by UV radiation, two types of fluorescence can be detected: 400 to 600 nm blue-green fluorescence (BGF) emitted from the more superficial layers; and fluorescence in the red and near-infrared range of 650 to 800 nm, emitted from the mesophyll. The blue-green fluorescence is mainly related to the hydroxycinnamic acids present in the cell walls. The



Map of Sangiovese Anthocyans 04:09, rated by Multiplex on 11/09/2012

fluorescence in the red and near-infrared range originates from chlorophyll a and is called chlorophyll fluorescence. Chlorophyll b, such as carotenoids in vivo, transfers all the energy absorbed from light to chlorophyll a. The intensity of the chlorophyll fluorescence depends, therefore, from the incidental light that reaches it. Only a part of the incidental light reaches the chlorophyll, because there are molecules in the more superficial layers, which absorb a greater or lesser amount of light depending on their concentration and their spectral absorption properties: this is the case of flavonols and anthocyanins. Thus, the fluorescence of chlorophyll decreases with progressing maturation.
Starting in 2010, Banfi has carried out a research, aimed at the evaluation of the application possibilities of fluorescence spectroscopy to monitor the phenolic maturation of the grapes in Sangiovese, Merlot, Syrah and Cabernet Sauvignon starting from veraison, carried out with a portable reader, easy to use in the fields (Multiplex). The trial required a first step of calibration of the reader, correlating the result of the destructive analysis with the readings obtained on the same samples. In September 2012, mapping was carried out of the accumulation of the anthocyanins in a vineyard of approximately 7 ha of Sangiovese, using the optical sensor, connected to a GPS tracking system. The non-destructive measurements carried out on the bunches, according to a grid of about 12 m x 12 m, for a total of 1400 readings, provided a mapping of the distribution of the anthocyanosides content in the vineyard.
Currently, we are studying the possibility of using these optical sensors for early detection of downy mildew in the latent stage, namely, before the disease manifests itself, so as to intervene with the utmost accuracy and timeliness.

3

Enhancement of the grape: from vineyard to winery, new goals and new technologies

After all the efforts to improve production in the vineyard, it is the winery's turn to contribute to enhance the specificity of the product. New technologies focus and optimize the experience of generations of winery experts, making knowledge objective and overcoming the discriminatory ability of the human eye, even if trained, as in the case of new cleaning and grape sorting systems.

3.1 The size of the berry: a marker of the enological potential of the grape

Among all fleshy fruits, the grape has earned the undisputed enological record due to its structural and composition characteristics that are really unique. It is, in fact, a fruit rich in both sugary and acidic pulp, enclosed in a thin tender skin and full of compounds of great enological value, among which polyphenols (tannins, flavonols, and, in colored grapes, also anthocyanins) and some families of molecules responsible for the varietal flavors of wines, such as: norisoprenoids, terpenes and benzenoids.
The composition and sensory properties of red wines, obtained with skin maceration during the vinification process, obviously depend crucially on the composition of the skins and the weight ratio of the skins to the pulp.
Accordingly, it is generally believed that smaller grape berries have a higher enological potential because they are characterized by a more favorable skin/pulp ratio. In fact, by simplifying the shape of the grape berry to a sphere, it is quite evident that with the increase in size, the pulp will increase in volume based on the cube of the radius, while the skin surface will grow only based on the square of the radius. Thus, with larger grape berries, there will be less skin in a certain volume, and consequently less "noble" metabolites will be available per unit volume of the grape juice (Fig. 3.1).
These considerations of a purely geometric nature can apparently be consistently validate when, for example, we compare the enological characteristics of table grape varieties with those of the vinifera varieties. The table cultivars have larger sized grape berries and give wines with little body, while vinifera cultivars, with smaller grape berries, are capable of giving structured wines. This comment, however, is only convincing on the surface. Indeed, we know that table grapes were selected for the thinness of the skin, while for wine grapes, that was not the case. The geometric considerations related to the ratio surface/volume of the grape, should therefore be supplemented by another size, the thickness of the skin. If upon the increase of the size of the berry,

there was a more than proportional development of the thickness of the skin, with the increasing weight of the grape, the weight ratio between skin and pulp would not necessarily become less favorable to the first (Fig. 3.2).
Numerous experimental studies carried out in recent years have indeed confirmed that, under equal conditions of development of the berry, the ratio between the weight of the skin and the weight of the berry tends to be con-

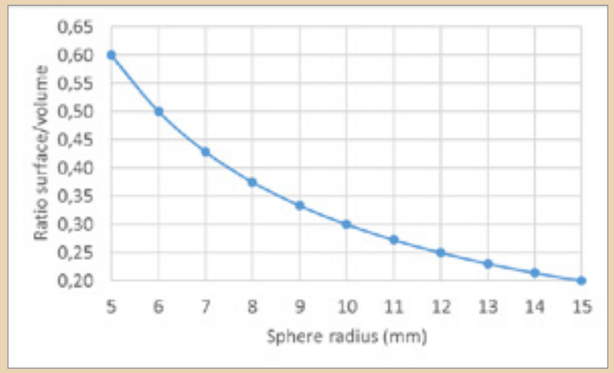


Fig. 3.1 - Relation between the radius of the sphere and the area/volume ratio. In large grape berries, the skin surface per unit volume of the grape berry is very modest compared to grape berries of smaller size. The mathematical function is represented by the hyperbola y = 3 / x.

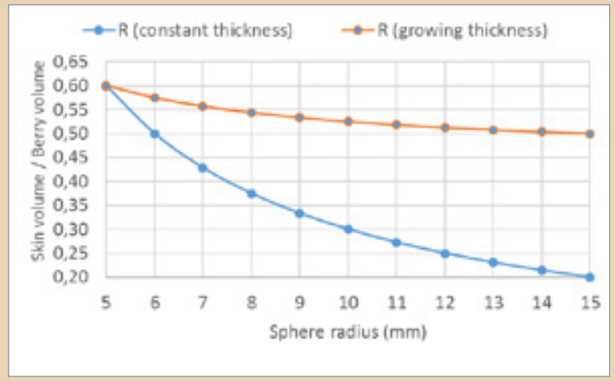


Fig. 3.2 – Theoretical relations between the skin and the berry volume with varied berry size, assuming a constant skin thickness (blue curve) and increasing thickness (red curve). If the skin grows in thickness with increasing grape size, the ratio tends to remain constant.

stant. In the same bunch, on the same plant and in the same vineyard, provided that this is marked by sufficiently uniform conditions, small grape berries and larger grape berries do not differ in the "skin-to-pulp" ratio because the development of the skin, in terms of thickness, tends to increase with the increasing size of the berry.
Matters, however, change significantly when the compared berries were developed under different physiological and environmental conditions. In this case, everything is called into question because there are numerous environ-

mental and physiological factors that guide and influence the development of the berries in quantity terms. These factors, moreover, will also affect the metabolic aspects, and add further "complications" to the physiological model under study. The enological potential of skin/pulp ratio is therefore not just a weight issue, but also a matter of "concentration" of metabolites. A thinner, but more concentrated skin, can have the same enological value of a thicker skin, but less concentrated.
These "viticultural physiology" considerations, which may appear excessive from a practical point of view, are in reality strongly linked to the concept of terroir. At the base of the complex interaction between grapes, soil, weather and climate conditions, cultivation techniques and grape quality is in fact a plurality of cause and effect mechanisms, which may act in individual pedology-climate contexts in a completely different way. This statement is even more true, as the variety of interest as in this case, Sangiovese, which is characterized by a high intra-variety with the environment and an elevated intravarietal genetic variability.
Which, then, are the main environmental and physiological factors that can change the relations between the size of the berry and its quality potential? The rate of fruit set, which depends on environmental and physiological conditions that occur in bloom, is undoubtedly an important factor. High fruit set rates inevitably lead to smaller grape berries due to competition for photosynthesis that takes place within berries of the same cluster. This does not necessarily lead to grape berries with thicker and richer skins.
The conditions of thermal energy and radiation that occur during the development of the grape berries are important for their growth. After fruit setting, the growth of the berry, supported by the process of cell multiplication, has a thermal optimum range between 20° and 25°C and is stimulated by light. Temperatures above 35°C, instead, inhibit the growth. Water and nutritional conditions that occur during the early development of the berries have similar importance. Water shortages and reduced availability of nitrogen reduce growth, with unpredictable results on the skin/pulp ratio.
It has been known for some time that the size reached by the grape berry at veraison imposes a limit to that which may reached at ripening. The final size of the berry depends, therefore, in a decisive manner from its size at the end of the herbaceous phase. What happens during ripening, in terms of the skin tissue development, however, it can greatly change the peel/pulp ratio. Conditions of water deficit, for example, further reduce the distension of the pulp compared to the peel, with the result of increasing the peel/pulp ratio.
The composition of the skin in terms of "enologically" valuable metabolites, obviously depends on environmental and physiological conditions that occur during ripening. The secondary metabolism of the berry is heavily conditioned by the heat and light micro-climate of the berry, and by its water status. Many of secondary metabolites have protective functions of plant tissues against oxidative stress induced by thermal and radiation excesses. Their synthesis is therefore stimulated by exposure to light of the berries and is positively correlated with the thermal regime to which the fruit is subjected, during both the herbaceous stage and during ripening. The accumulation of these metabolites is however the result of the difference between their synthesis and oxidative degradation. The degradation, in fact, responds exponentially to the increasing temperature of the berry. Therefore, typically, the greatest accumulation of secondary metabolites occurs at temperatures between 20-25°C versus higher temperatures (25-30°C), which also have a positive effect on synthesis. Condition of elevated light radiation, associated with temperatures of 20-25°C, are those most favorable to the accumulation of secondary metabolites. Conditions of elevated sun radiation occur when the sky is clear, which favors a higher day-night temperature excursion. For this reason, and not due to the temperature excursion effect itself, the accumulation of secondary metabolites areoften positively correlated with high temperature ranges.
Considering some classes of secondary metabolites accumulated in the berries,

and especially in the skin, of vitienological interest, it is possible to trace the following synthesis overview.

Anthocyanins. The synthesis is stimulated and anticipated by the direct exposure of the bunch to light. The final accumulation of anthocyanin is, however, the result of the difference between synthesis, also stimulated by light and maximum at temperatures of 25-30°C, and the oxidative loss, positively and exponentially correlated to the temperature of the bunch. Typically, then, the highest accumulations are found in conditions characterized by daily maximum temperature of 20-25°C and in bunches that do not undergo thermal excesses due to direct exposure to solar radiation. In bunches subjected, instead, to thermal excess (> 35°C), the accumulation is negatively affected by the increase of oxidative losses. The water deficit conditions stimulate the synthesis of anthocyanins, and can compensate for the effects of thermal excesses.

Flavonols. They are definitely the class of polyphenols more responsive to solar radiation and specifically to the UV component. Their concentration can be considered a marker of the radiation environment in which grapes developed and ripened.

Phenolic acids. The synthesis and accumulation of phenolic acids seem to respond primarily to light radiation conditions.

Terpenes. Their synthesis in free form, and particularly in glycosylated form, is stimulated by exposure to light of the grape berries. The thermal excess (> 30-35° C) increase the oxidative losses and result in a reduction of the accumulation.

Norisoprenoids. The thermal and light conditions associated with their final accumulation in the grape berries are not well known, even if the concentration of carotenoids, their precursors, increases in conditions of higher exposure to light. The final accumulation in the grapes, due to their synthesis during ripening, seems to be encouraged by the conditions of exposure of the grape bunches to light; however, it is not positively correlated with the amount of carotenoids present at veraison in the same grapes.

In light of this complex network of cause and effect relationships between environmental and physiological factors, berry size, skin size and composition, the winemaking Management at Banfi asked itself whether and to what extent the average weight of the berry provides useful information in estimating the enological potential of the grape. It is a question of great practical significance. Having such an easy marker to detect for evaluating grape quality potential would mean having a diagnostic-economic tool of great information impact.

The trial investigation

Precisely for this reason, in the two-year period of 2012-2013, Banfi decided to undertake a study to learn more about the relation between the size of the berry, ratio of skin-to-pulp, and technological and phenolic ripening profiles, given the broad soil variability present in the Estate. For this purpose, the trial data collected in 20 representative vineyards of the Estate landscapes, of a similar age (between 7 and 10 years) and, where possible, of the same clone: Janus 50. In each, representative plots of about 100 vines were identified, each then divided into three sub-plots for a total of three replications for main plot. In each sub-plot, at pre-veraison, a number of evalutations were made relating to the state of the foliage: size of the canopy, empty canopy, leaf layers, external and internal bunches, level of lateral growth, leaf size, active growing apexes, and wilting symptoms at midday.

At harvest, six bunches were collected for each sub-plot, representative for size and exposure. In the laboratory the following determinations were performed: weight of each bunch, weight of grape berries, weight of the skins, weight and determination of the number and the color of the seeds. The sampled bunches were used for analysis of technological ripeness (sugar, pH, total acidity and malic acid) and the analysis of the phenolic maturity of the skins (anthocyanins and total polyphenols) and seeds (total polyphenols).

Taking into account the specific location of the trial plots within the Estate's soil map and of the controls carried out through precise field surveys, the soils of the vineyards were classified from an operational point of view into two main categories: "limiting" soils and "not limiting" soils based on the following soil descriptors regarding habitability of the soil: skeleton, texture, depth, available water holding capacity (AWC).

Thus, soils characterized by a clay texture, reduced depth, high skeleton in topsoil and low water availability were classified as limiting. In contrast, medium-textured soils, with greater depth, a reduced content in the skeleton and a good water supply were classified as non-limiting.

The results

From climate point of view, the two vintage years under study were characterized in a contrasting manner. 2012 had a relatively early, rainy spring, followed by a hot and dry summer. 2013, by contrast, was characterized by a cool and rainy spring and summer (Fig. 3.3).

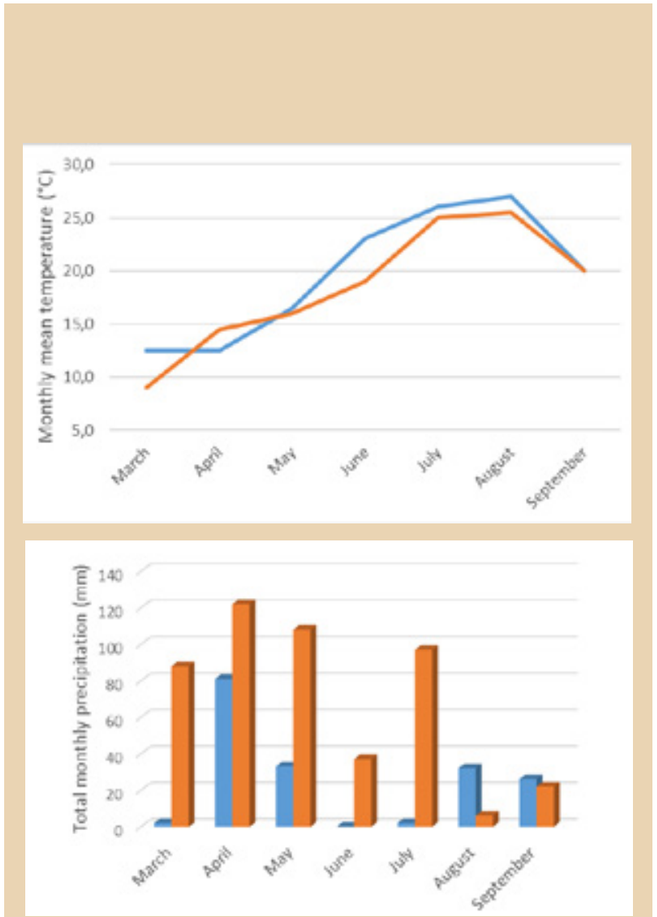


Fig. 3.3 – Performance of temperatures (left) and rainfall (right) in the two vintage years of study. 2012 (in blue) was a vintage with greater thermal resources and reduced availability of water resources compared to 2013 (in orange) that was extremely rainy from March to July.

These differences in temperature-rainfall courses markedly differentiated the vintage years in terms of mean weight of grape berries (Fig. 3.4) and skin/berry pulp ratio (Fig. 3.5).

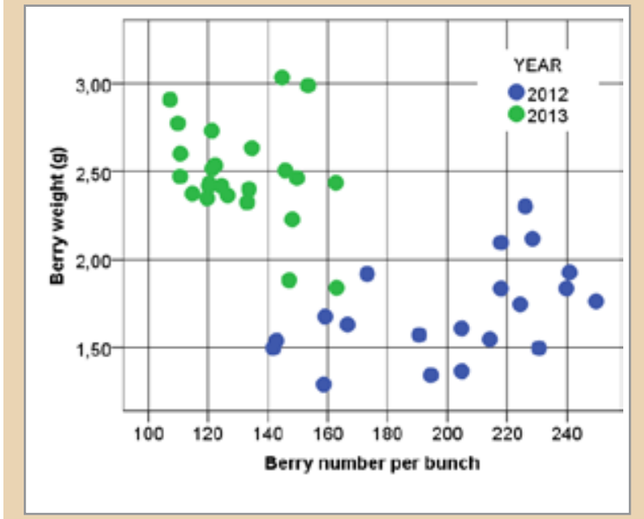


Fig. 3.4 - Relation between the number of berries per bunch and mean weight of the berry at ripening.

To be noted that in 2012 the temperature and radiation conditions during flowering have fostered a good fruit set compared to 2013, which, on the other hand, was negatively affected during flowering by persisting rain. This aspect, jointly with the conditions of the water status of the plant during the two years, had a decisive influence on the berry size at ripening: modest size berries in 2012 and larger size in 2013.

Note how generally the growth of the skin follows that of the berry, even if between the two vintages the incidence of the skin is very different: between 40-50% in 2012 and 10- 20% in 2013. These differences reflect the different environmental and physiological conditions that occurred during the development of the berries, with profound differences at tissue level in development of the berry. The data show how the relative thickness of the skin plays an

important role in defining the skin/berry relation, which can not be attributed to the simple geometric ratio between surface and volume of the sphere.

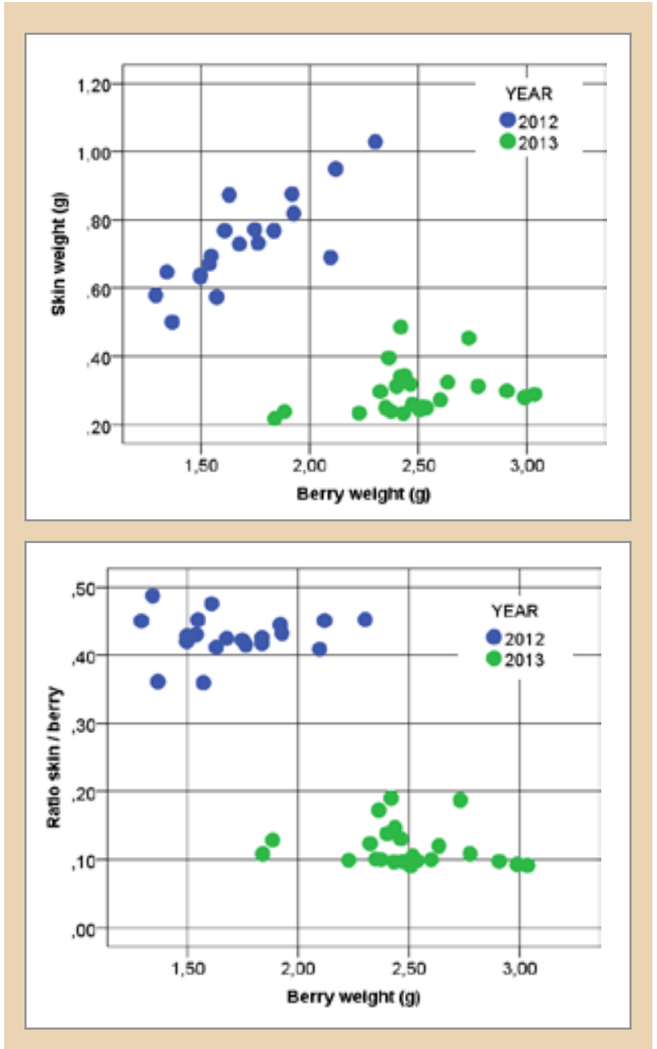


Fig. 3.5 Relationship between the weight of the berries and weight of the skins (left), and the effect of the skin-to-berry ratio on the berry weight (right).

The technological ripeness profile of the berries appears only partly conditioned by size (Fig. 3.6). In 2012, the relation between berry size and sugar content was particularly evident, which was not the result in 2013. However, the most comprehensive levels of technological ripeness were also obtained in 2013 in the conditions in which the development of the berries was more reduced.

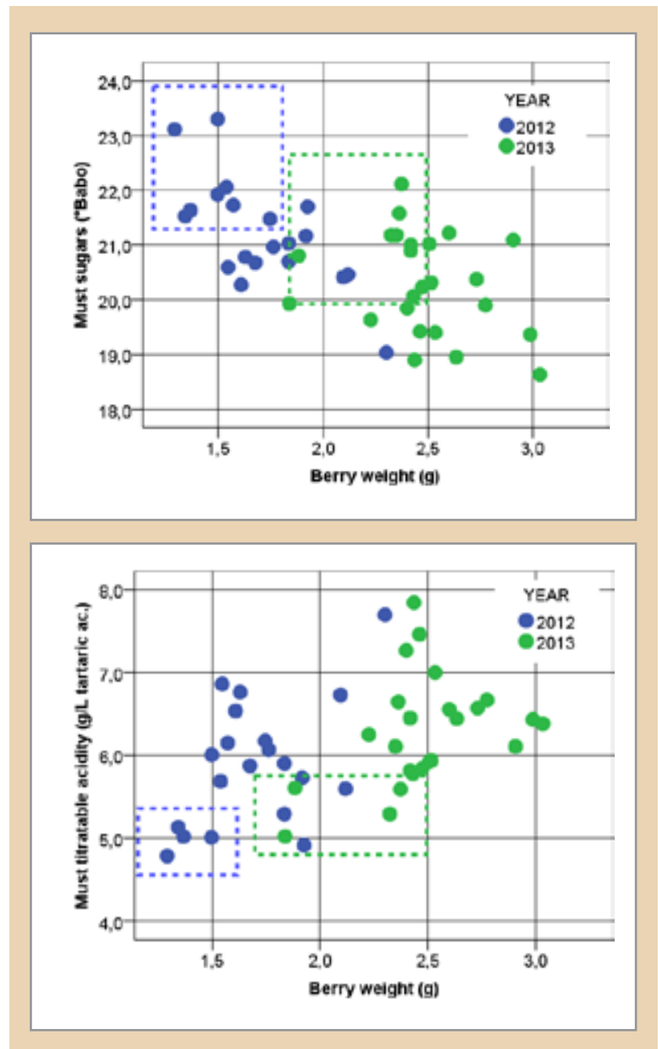


Fig. 3.6 - Relation between the weight of berries, sugar levels (left) and titratable acidity (right) of the must. The circled areas in the graphs highlight how, during the two vintage years, the most complete ripeness was reached by the smaller berries.

Also, regarding the phenolic ripeness, the level of anthocyanin accumulation expressed per unit of grape weight resulted to be tied to the size of the berry. In both years, the highest anthocyanin concentrations were obtained under the same conditions that determined the smaller sizes of the berries (Fig. 3.7).

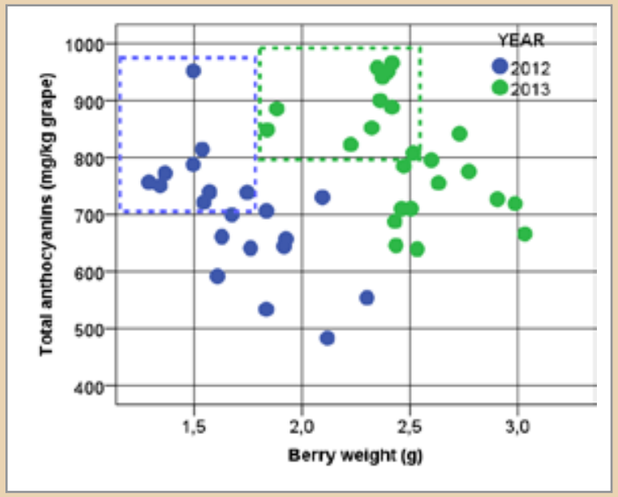


Fig. 3.7 – Levels of anthocyanins in relation to the size of the berry in the two vintages. During both years, in the vineyards where the berries were smaller, the highest accumulation of anthocyanins was obtained.

The survey highlighted that the two central aspects that affect the final amount of anthocyanins in grapes, namely their capability of accumulation (the reservoir capacity), tied to the proportion of skin in relation to the berry, and the occurrence of favorable conditions for synthesis and concentration (ability to fill the reservoir) on behalf of the skin tissues, are complementary between them. In fact, in both 2012 and 2013 the final anthocyanins levels were significantly correlated with the skin/berry ratio, and with the storage capacity of the skins (Fig. 3.8). If in both vintages the "reservoir" effect was similar, in 2012 the role of the accumulation ability of the tissue of the skin, however, was higher (Beta

coefficient = 1.229) compared to what occurred in 2013 (Beta coefficient = 0.502). The higher role of the synthesis ability of the skin in 2013 reflects the lower thickness of the skins found that year.

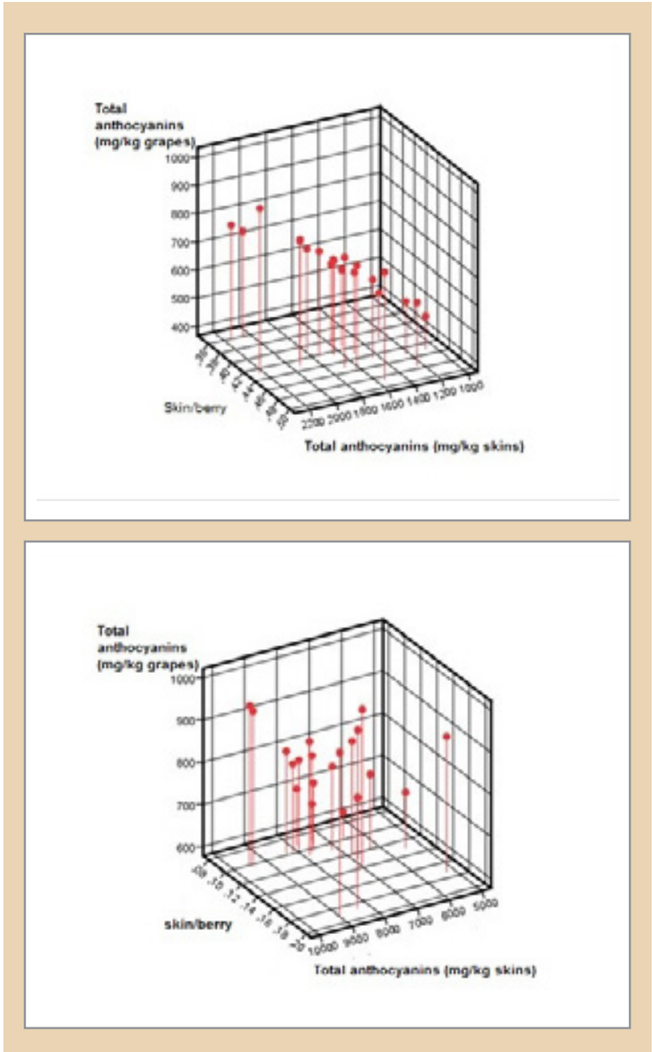


Fig. 3.8/a – Multiple regression model that relates the amount of anthocyanins per grape weight units with the amount of anthocyanins per skin weight unit and the skin/berry relation.

Coefficients [a]

YEAR	Model		Not standardized coefficients B	Not standardized coefficients Standard error	Standardized coefficients Beta	t	Sigma
2012	1	(Constant)	-761,971	50,671		-15,038	,000
		Skin / Berry	1772,350	92,604	,516	19,139	,000
		ANT. TOT. mg/kg skin	,425	,009	1,229	45,623	,000
2013	1	(Constant)	280,525	141,123		1,988	,063
		Skin / Berry	1790,449	560,720	,563	3,193	,005
		ANT. TOT. mg/kg skin	,043	,015	,502	2,846	,011

a. Dependent variable: ANT.TOT.mgkgskin_mean_mean

Summary of the model

YEAR	Model	R	Square-R	Correct Square-R	Standard error
2012	1	,996[a]	,992	,991	9,85488
2013	1	,695[a]	,483	,422	74,34424

a. Predictors: (Constant), ANT.TOT.mgkgskin_mean_mean, BuBa_mean_mean

Fig. 3.8/b - The two lower panels show the multiple regression models (left) and relevant multiple regression coefficients (right). Please note that the Beta coefficient in multiple regression models expresses the standardized weight of the independent variables on the dependent variable. In our case, the former are represented by the skin/berry ratio (reservoir size effect) and the latter by the berry skin's tissue synthesis capacity (actual capacity of the skin to fill the reservoir). The dependent variable is in this case the amount of anthocyanin per unit of grape weight.

Finally it must be emphasized how the environment factor that affects both the size of the berry and the ability to accumulate anthocyanins is at least partly attributable to the capacity of the soils to induce a state of adequate water deficit in the course of the development and the ripening phase of the berry, according to the classification adopted in this experimental survey (Fig. 3.9).

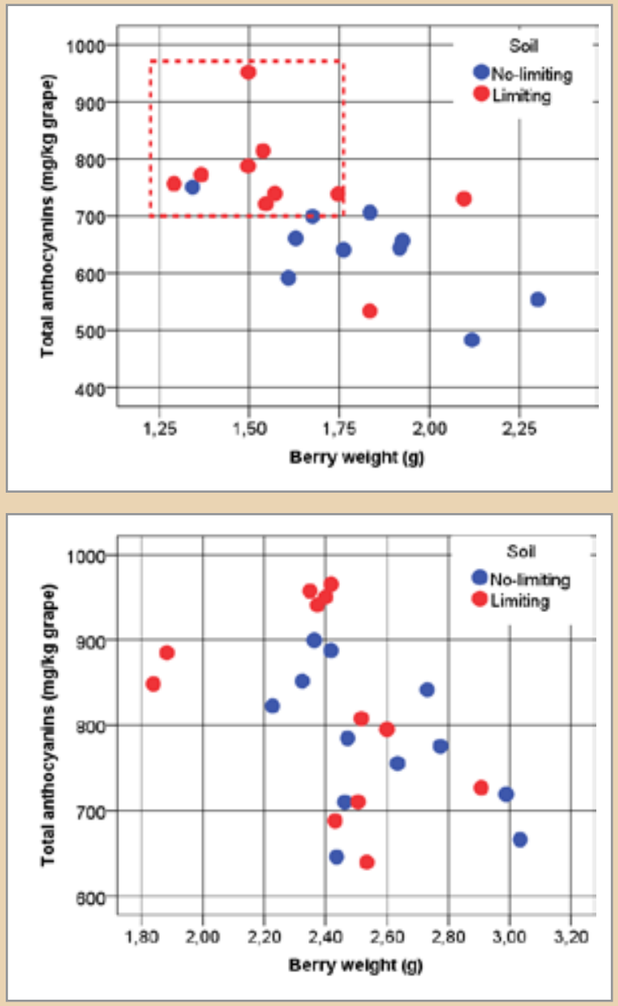


Fig. 3.9 – Anthocyanins accumulation levels and size of berries in 2012 (left) and in 2013 (right) in relation to the classification of the vineyard according to the presence of "limiting" or "non limiting" soil. Note how in 2012, in the majority of soils classified as limiting, smaller berries and more accumulations of anthocyanins were obtained. In 2013, the scenario was less clear.

Conclusion

The data collected during the two-year experimentation suggest that the berry size can be considered a valid estate marker for the classification of the vineyards in terms of anthocyanin accumulation capacity. The physiological relation between size of the berry and ability to accumulate anthocyanins does not appear to be, however, the consequence of structural aspects of the berry, namely from the ratio of the area of the skin and the volume of the pulp. This relation is, in fact, independent of the size of the berry. The greater capacity of small berries to accumulate anthocyanins therefore seems not a direct result of their smaller size, but rather the result of a convergence of environmental causes. Soil and physiological conditions that cause the berries to develop less would seem to determine, during the ripening of the grapes, favorable conditions to the synthesis and accumulation of anthocyanins.

This brief note is a synthesis of a study mainly by Matteo Perfetti, Simone Barbato and Dario Sini, at that time graduands of the masters degree program in Viticultural and Enological Sciences as part of the research for their thesis, with the full support of the technical and enochemical analysis laboratory staff of Banfi srl.

3.2 Enhancement of red grapes, cleaning and sorting techniques

In order to produce a quality wine it is increasingly important to process grapes in perfect conditions, in terms of ripeness, health and entirety. These objectives, in many estate situations, are difficult to reach; furthermore, it is also not easy to univocally identify the quality of the incoming grapes that have the sugar content as a general reference, but nothing regarding their level of cleanliness and compliance with the production target.
In the Italian wine industry, various harvesting and sorting techniques are used and increasingly quality wine companies resort to mechanical harvesting, for both the timeliness of intervention that the machine ensures and for the consequent reduction in labor costs. The critical points that differentiate mechanical harvesting from hand harvesting are related to the alleged poor sorting

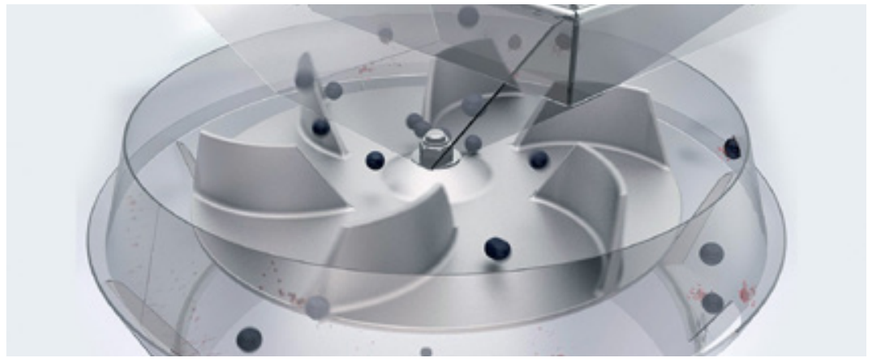
capacity of harvesting machines. In fact, if with hand picking the trained worker has the option to discard all that is deemed not suitable for vinification, the machine harvests everything, including fragments of leaves and stems, as well as foreign materials, which remain in the pressed product until it reaches the fermentation tank; this fraction, consisting of organic and inorganic substances, is defined as MOG (Material Other than Grape). Another problem concerns the collection of grapes that are not completely ripe. The term ASM (acini a scarsa maturazione or insufficiently ripened berries) indicates those berries that have not reached, during ripening, characteristics required for the production of quality wines. Finally, grapes affected by molds or rotting grapes are also sorted, which would be discarded with the manual harvest.
To improve these aspects, grape harvesters have evolved considerably over time, becoming increasingly efficient and less invasive on the vineyard, equipped with a destemmer and defoliator on board in order to reduce the green fragments in the grapes.
In order to further improve the quality of the grapes, before placing them in the vinification vats, the most demanding companies, in quality terms, use various post-harvest sorting systems that can be divided into two large categories: manual sorting systems, with the presence of workers carrying out the selection; and automatic sorting systems that, on the contrary, use different principles: mechanically separating MOG and ASM, or selecting the grapes, based on their quality and theoretically capable of controlling each berry at a level that cannot be reproduced by hand. In this way, they carry out a more consistent and efficient process compared to any other type of sorting, including the one that uses human resources.
There is also another widely used technique in quality winemaking, which is sorting in the vineyards prior to the intervention of the harvester. In this way, workers remove all those bunches that visually present insufficient ripening conditions or ones with less than optimal health levels. The harvester thus collects only what is left. Basically, it is an advance of the sorting process.

The selection systems at Banfi

For years now, Banfi carries out ta post-harvest sorting method, using three different selection systems for incoming red grapes, one of which is of a mixed type (automatic-manual) and two automatic systems that adopt different processing technologies.

Manual sorting on belt, Selective Process Winery and Selective Process Vision - Pellenc

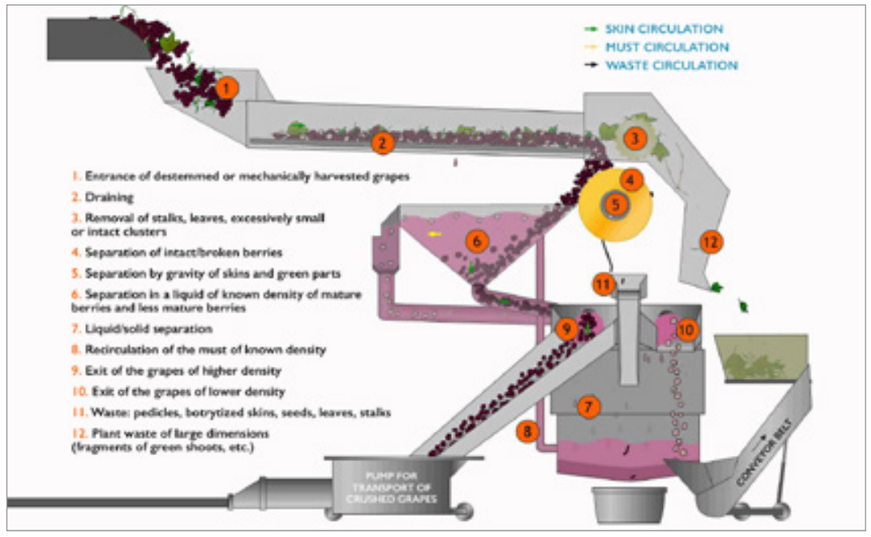
This is a system used exclusively on hand-picked grapes that undergo an initial selection in the vineyard. It is characterized by having two selection areas, a manual area before the destemmer (bunch selection) and an automatic area after the previous (quality selection of the berries). This system is characterized by a sorting conveyor with a food grade PVC belt on to which the harvested grapes are unloaded by a vibrating feed hopper, which facilitates the distribution of the grapes on the belt. On the sides of the sorting belt, four workers (two on each side of the belt) manually separate the parts to be discarded (green parts, bunches that are insufficiently ripe or with phytosanitary problems).
In addition to the sorting belt, there is also a high-frequency linear stem separator (Selective Process Winery - Pellenc). It is a system with destemming modules, which gently detaches the grapes from the bunches leaving them intact. Itis also equipped with a table with rollers at a variable sieve to allow the removal of plant residues and stalks without tearing the latter.
The de-stemmed and perfectly intact grapes are transported directly through an optical sorting system (Selective Process Vision - Pellenc) which represents the second part of the system. This device consists of: a perforated vibrating table, which evenly distributes the grapes and drains the liquid from the grapes; a conveyor with parallel cables, which facilitates the progression of the grapes towards the artificial vision block. The latter includes a lighting system and a video camera for capturing moving images. The optical selection process is managed by a computer, which interprets the images acquired by the camera and controls a pneumatic expulsion system composed of ninety-six air nozzles at very high frequency arranged above the flow of grapes that allow the elimination of the undesired elements (MOG and ASM). These fall into a



hopper equipped with a flexible screw that runs orthogonally in respect to the appropriately selected grape flow. The system described above has a capacity ranging between 8 and 10 t/h depending on the variety of grapes processed.
The berries selected by the optical system are pressed before entering the fermentation tank by means of a dynamic crushing system (Extractive - Pellenc) that, thanks to the use of a rotor with blades, prevents the breaking of pips allowing to limit the supply of tannic components that make the wine herbaceous and bitter.

Tribaie - Amos Densimetric Sorter

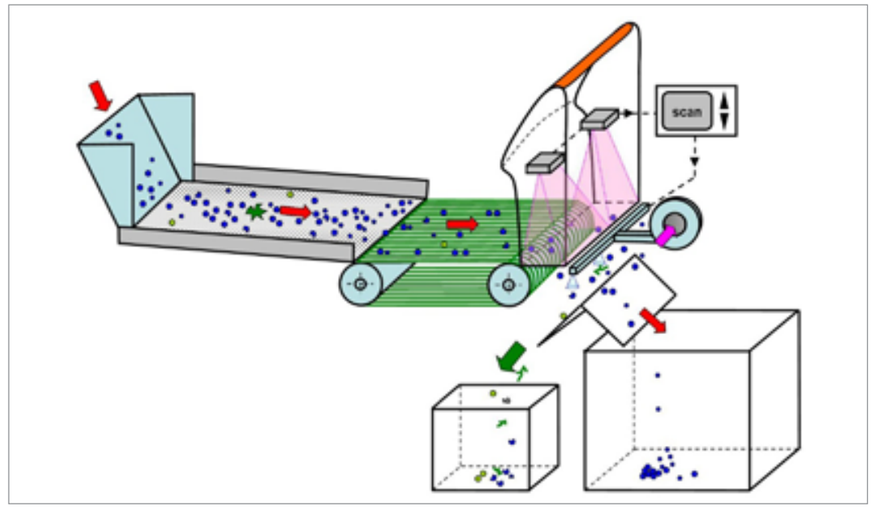
This is a device that enables the automation of the sorting of destemmed grapes and for this it has been included in a receiving line of mechanically harvested grapes. The machine is filled with 2 t containers. The grapes in the containers are discharged into a vibrating tank that doses the quantity necessary for system operation.
The machine performs two actions in a single step: it separates the fragments of stems, leaves and leaf peduncles (MOG) by way of mechanical removal and carries out a quality separation of the berries, in order to carry out separate vinification, depending on the quality of the grapes. The process is carried out by contact and densimetry. The first level of sorting is based on the rotation of a cylinder composed of many toothed discs following the passage and the



sorting of the incoming mass of grapes on a vibrating table. In the second level of sorting the berries fall onto a rotating roller, which separates the berries into two categories, according to their consistency. The intact berries, in fact, do not adhere to the roller, while not perfectly intact or crushed berries and only the skins, attach to the roller and are expelled.
During the final level of the sorting of the sorting of the grapes, immersed in must with a fixed sugar content, the grapes are separated according to their level of ripeness by way of a densimeter principle (Archimedes' principle). The ripe berries, with a higher density compared to that of the must, fall to the bottom, while the unripe berries, with a lower concentration of sugar and consequently a lower average density than that of the must, rise to the surface of the densimetric vat. The two different categories are collected separately, allowing to obtain two different quality classes of grapes: (i) completely ripe and clean berries; (Ii) not completely ripe berries (ASM).
The hourly flow rate of the system, for this version in the winery, is approximately 10 t/h.

Delta R2 Vistalys - Bucher Vaslin Optical Sorter

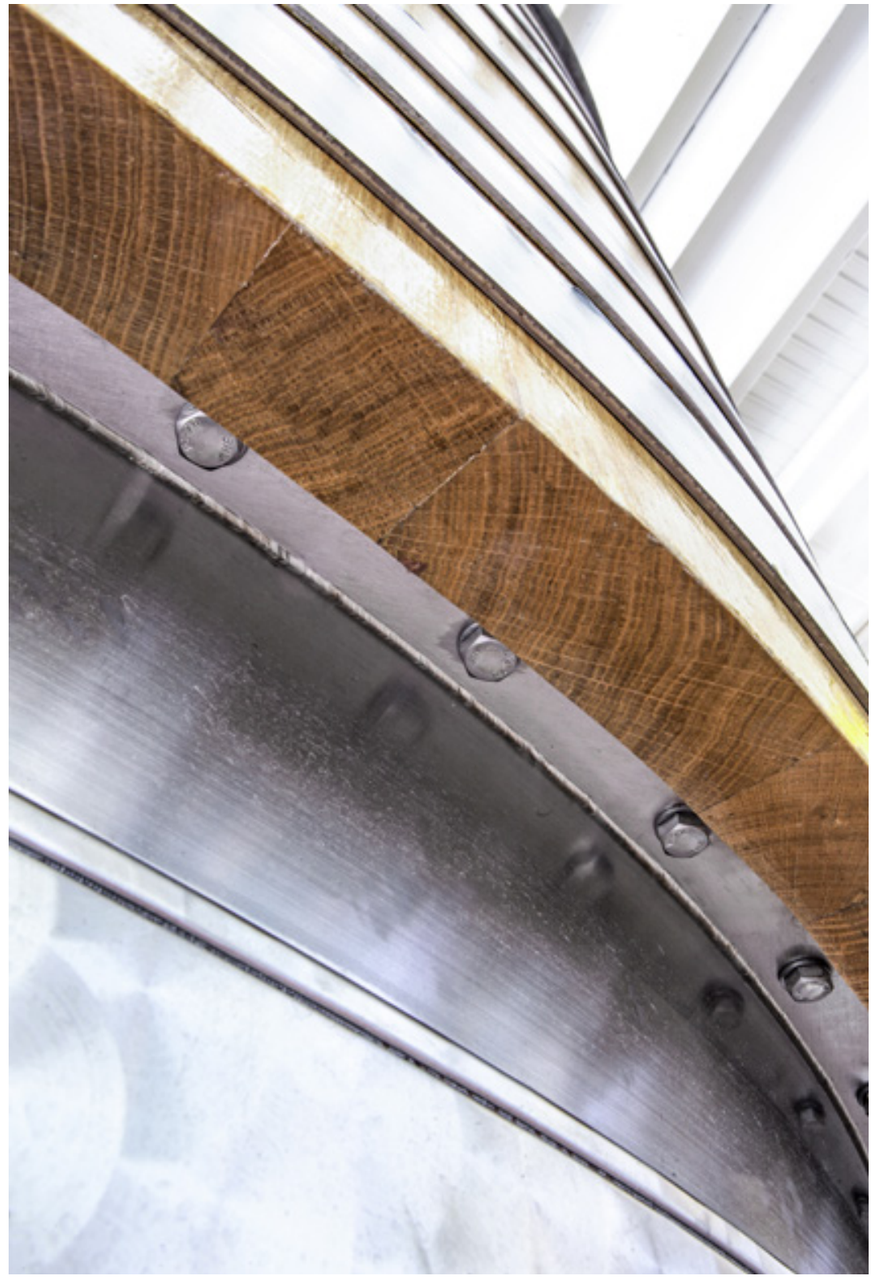
The winery has an additional machine for the selection of mechanically harvested grapes. Like the densimeter selector, itis integrated into a receiving line dedicated to mechanically harvested grapes. This device is characterized by a precision optical sorter that picks the berries according to the desired quality characteristics.
Also in this case, the destemmed grapes are placed inside the vibrating collection vat from a 2-t bin. Before the collection tank is a vibrating table, which drains and homogeneously distributes (single layer) the berries, helping them slide inside the optical selector which is equipped with a rubber conveyor belt, with reliefs (pegs) evenly distributed over the entire surface, to ensure the stability of the material to be scanned.
The optical analysis is performed at high speed and requires constant and focused lighting on the area to be observed, guaranteed by a LED lamp. A color video camera captures the images of the objects illuminated by the LED light on a contrasting background. The images are processed by a computer according to a principle based on the positioning and the correlation of the colored pixels compared to the others.
After analyzing the images, the system automatically carries out the expulsion of unwanted items through high pressure compressed-air ejection nozzles. An operating system, called HMI (Human Machine Interface), allows to define the sorting criteria via preset and modifiable programs. You can decide to select only perfectly ripe and morphologically intact grapes or decide to limit the selection, accepting crushed berries or berries with stalk residues.
The optimal use of the machine foresees, at the beginning of each selection process, the preparation of a sample, composed of grapes that meet the needs of the winery. This sample is viewed by the optical selector, which captures images of the berries and of their characteristics (color, size, shape and surface of the possible defects) using them as a reference. Once the lot of grapes has been scanned by the machine, they are divided into first and second choice grapes. In the first, there are the berries that most closely match the characteristics of the reference sample; the second is composed of unsuitable berries (ASM) and waste from the vineyard (MOG).
At any moment of the process, the preferred color or shades can be selected, from one or more berries. This allows to intervene during the selection, choosing the color of the discarded material or of the product that is passed. The visual inspection of the adjustments improves the result since the operator can vary the selection parameters based on incoming grapes, avoiding a new acquisition phase of the sample type. Under conditions of indicated use, the machine can reach 10-12 t/h of maximum production.
Over the years Banfi has compared the two different selection systems of mechanically harvested grapes that the estate uses, allowing an initial assessment of the potential and use opportunities in the processing of grapes, in in order to optimize the quality of vinification. Note that the Tribaie sorter works, after an initial mechanical selection of the MOG, according to a densimeter



comparison, in order to select two different levels of ripeness depending on the concentration of sugar, while the Bucher machine uses a system of recognition and comparison of images to accept the material or discard what it classifies as MOG or grapes of unacceptable sizes.
The results have distinctly shown that, in the case of elevated heterogeneity of grapes due to geopedological factors of the plot from which they originate or due to other external reasons, the Tribaie system is the more efficient because it chooses grapes with the best composition, enabling the estate to reach its specific vinification objectives. On the contrary, in consistent ripening conditions, the selection made by Tribaie appears not to be significant, since there are no substantial differences in the ripening levels of the berries, while the most efficient elimination of MOG and of abnormal berries by the Bucher machine leads to an increase of the quality of the resulting wines.
In conclusion, in our scenario, the Tribaie sorter appears to be the machine best able to increase the quality levels of the products. However, it is appropriate to point out that in the case of the Bucher machine, the performances can be suitably modulated and guided by the choice of parameters in order to set the selection method, as it is an optical system by comparison. In less diverse environments, with regard to landscapes and different production objectives, it can be considered most suitable compared to what emerged from our experiences.

3.3 The HORIZON fermentor

After a few vinification tests carried out in composite truncated conical vats with different capacities, and in light of the positive results obtained in 2007, a new vinification area was built consisting of 24 truncated conical oak and steel vats of 177 hl.
The outstanding features of the HORIZON fermentors are the following:
1. central truncated conical oak body, topped by a truncated conical steel extension, with a jacket to cool of the cap; the staves are attached to a cylindrical steel body with a jacket to heat the must or wine;
2. discharge is carried out by a rotating blade which pushes the pomace towards the port;
3. steel base consisting of a cone with its vertex facing upwards. The grape seeds that slide towards the base of the inclined surface deposit on this cone and, if need be, can be removed;
4. ability to pump the must, from the bottom, above or below the pomace cap, depending on the phase and fermentation method used; during pumping the must can be oxygenated;



5. positioning of the fermentors on a dedicated steel tank, which may serve as a storage tank when "delestages" is carried out or for other operations (oxygenation of the must, cooling or heating in the heat exchanger before pumping over or "delestages").

Technological benefits obtained with the Horizon fermentor

• Option to cool the cap avoiding a further increase in temperature of the fermenting must. Hence:
1.1) less extraction of excessively astringent compounds;
1.2) ability of obtaining wines with more readiness and ripeness.
• Maintaining the set temperature of the must and solids, inside the vat, at programmable levels depending on the style of the wine. Hence:
2.1) Lower partial loss of the anthocyanins by absorption on the solid parts present or by precipitation together with the potassium bitartrate crystals (phenomena facilitated by the decrease in temperature);
2.2) Increase in yeast lysis, with an enrichment of mannoproteins of the wine.
• Option of optimal management of fermentation, post-fermentation maceration, malolactic fermentation and aging problems due to the integration of a cooling system at the top and a heating system at the base of the vat.
• Option of directing the must under the cap at the beginning of fermentation in order to facilitate the reproductive activity of the yeast without involving the skins, thus avoiding the extraction of anthocyanins, or above the cap in the case of normal pumping over. Hence:
4.1) Deferred extraction of the anthocyanins in order to reduce the extraction and oxidation reactions, also for the oxygenation effect of the must under the cap and the delay of the pumping over operations involving the skins. In other words, the pumping over under the cap with the oxygenation of the must enables to provide the oxygen necessary for yeast activity, avoiding the involvement of the anthocyanins that remain in the cap in the coupled redox reactions, induced by the PPO of the grapes, active at the start of fermentation. When the must has reached an alcohol content of 5-6% v/v and the tannins from the skins and seeds can efficiently be extracted, then the pumping over can involve the cap without risks of the oxidation of the anthocyanins.
• Racking operations carried out by gravity with extraction of the pomace facilitated by the shape of the bottom and by the presence of an extractor with rotating blades.

Further notes

The innovative construction of the wood vat with the lower and upper parts in steel allows for an easy replacement of the wooden body, when its functions are depleted. Should the wooden part be used only to contain temperature fluctuations in the post-fermentation and aging, the staves can be replaced also after long periods of use, with attention to appropriate sanitization of the vat along with all necessary practices to avoid contamination of undesirable microorganisms. Should the wood be chosen to supply flavors and oxygenation of the wine, periodic replacement after appropriate controls must be carried out. By acting on the width of the staves, it is possible to increase the efficiency of the transfer of tannins and aromas from the wood; the costs of this operation must be considered according to the desired results.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Specific benefits of the wooden body

• Low thermal conductivity of wood, which enables to keep the temperature at the programmed level for significantly longer times, compared to the steel container. This is important in the post-fermentation phase, to avoid losses in anthocyanins, and in the management of malolactic fermentation. Furthermore, the wine held in wooden tanks, during aging, avoids dangerous thermal shock to the polyphenolic stability and redox.
• "Calibrated" microporosity of wood allows micro quantities of oxygen to transition to the wine resulting in an optimal development of anthocyanins, improving color and flavor of the wine. The substances conveyed by the wood and the small amounts of oxygen that pass into the wine are able to efficiently adjust the phenomena of yeast and fermentation.
• Ability of obtaining the positive results obtained during the "white" vinification also for the "red" vinification: more stable wines, less astringent, with a softer and more complex flavor.

Function of the lower steel tank

The Horizon fermentors were equipped with additional tanks that, in order to optimize the space inside the winery were placed on the lower level. These tanks are mainly used to receive the wines drawn from the upper vats, without the use of pumps, thus avoiding oxidative stress. They can also be used as vats to receive the must during fermentation if "delestages" is intended. Therefore, depending on the requirements, the must can be oxygenated or transferred into the vat away from oxygen. The lower tank can also be used as a storage tank or during racking for clarification or oxygenation.

Vinification tests carried out
In the last few years, we compared the new truncated conical tanks with traditional fermentation tanks, adopting various maceration techniques:
1. Banfi Traditional Fermentor- traditional vinification
2. Banfi Horizon Fermentor - traditional vinification
3. Banfi Horizon Fermentor - cold maceration
4. Banfi Horizon Fermentor - deferred maceration

The alternative vinification procedures tested were as follows:
1. Cold maceration, consisting of the following operations:
• cold pre-fermentation, after treatment with CO2 of intact or destemmed grapes placed in the vat and kept for 3-4 days at a temperature of 4-5°C;
• subsequent heating to 18-20°C and then inoculation with appropriate selected yeast; in this phase the cap must be kept cold;
• aeration of the must from under the cap when the alcohol content reaches 2-3% vol. without involving the cap and with the addition of ammonium salts;
• based on the test results, a further pumping over with air with the addition of ammonium salts may be carried out, again without involving the cap; when the alcohol will have reached 5-6% vol. pumping over can be planned that also involves the cap.

2. Deferred maceration, which involves the following operations:
• topping with CO of the fermentor and pressing of the grapes with the addition of selected yeasts;
• as soon as the cap forms, the must, lightly rosé, is transferred into the lower

tank and is maintained at a controlled temperature of 20-22°C with the addition of oxygen (air) and ammonia salts;
• the cap will remain at the bottom of the fermentor, where the temperature can be controlled, with a small amount of must;
• when the alcohol inside the cap will have reached 6-7 degrees of alcohol, the fermenting must which is in the lower tank will be added back in part, or totally;
• at this point, the pumping over involving the entire mass will begin, with the possible addition of oxygen (replacement air) and ammonia salts if necessary;
• Depending on the V/P ratio, the duration of maceration will be decided on.

Results

The comparison between traditional Banfi vinification (TT) and vinification carried out in Banfi Horizon tanks with three different maceration techniques: "Traditional Banfi (TNV)", "Cold maceration" (MFNV) and "Deferred maceration" (MDNV) brought the following results.
Alcohol content, Titratable acidity, pH. The alcohol content detected on the wines in aging have presented no significant differences in the four tests. This fact indicates that the batch of grapes used for the four vinifications were sufficiently homogeneous. In any case, with the wines with good structure represent an average sample of the Sangiovese cultivar cultivated in Tuscany. It seems interesting to note that in the early stages of the winemaking process the alcoholic fermentation (FA) was faster in the "traditional sample" (TT) and slower in the "traditional new vinification" (TNV), in an intermediate way in "cold maceration new fermentor" (MFNV) and "deferred maceration fermentor" (MDNV). At the end, the TNV test had the highest alcohol content. The homogeneity of the grapes can also be gathered by the uniformity of the titratable acidity and pH data of the four tests. Due to malolactic fermentation (MLF) and tartaric precipitations that the test led to, the titratable acidities decreased by approximately 1 g/L (expressed as tartaric acid) and the pH increased to about 0.1 units, versus racking. The data of the volatile acidities, very low before MLF, show that the alcoholic fermentation was carried out correctly, without delays or blocks. The increase of this parameter after MLF was expected and constitutes a normal fact (e.g., follows the attack of citric acid by lactic acid bacteria).
Total anthocyanins: the anthocyanin extraction, from pressing to approximately mid-alcoholic fermentation, was faster in the "traditional sample" (TT). The slowest diffusion of anthocyanins in the "traditional new fermentor" (TNV) tests and the "cold maceration new fermentor" (MFNV), however, did not af-

fect the overall extraction of these compounds, the content of which, at the end of alcoholic fermentation was higher in these two tests. All this indicates that a part of the anthocyanins, extracted faster in the TT tests, was degraded, probably by oxidation in the first phases and during the alcoholic fermentation. Even though the differences between the total anthocyanin content in the four tests were attenuated at racking, after FML and in the first phases of the aging process of the wines, the highest content of these pigments were found in the last test in MFNV, with the lowest ones in MDNV. The differences between TNV, NFNV and TT are, however, very contained.

Anthocyanins monomers: essentially, the data of the anthocyanins monomers confirm that the extraction of these compounds was faster in the TT test and that it induced an evident consumption of these compounds since, subsequently, a more rapid decline was found. During fermentation and in the subsequent phases of racking and FML the differences between the four tests decreased.

Proanthocyanidins: at approximately mid-alcoholic fermentation, the MDNV test had the highest content in proanthocyanidins (flavanol oligomers and polymers), the TNV and MFNV tests had the lowest values. At the end of the alcoholic fermentation, the differences between the four tests were not very perceivable, but the TNV and MFNV had the highest values of this class of polyphenols. These differences were maintained at racking and after MLF and increased during aging. It seems evident that even the extraction of proanthocyanidins was faster in the initial phase of maceration in the TT and MDVN tests but also that the slow extraction found in the TVN and MFNV tests led to a reduced loss during the final phases and in the product during aging.

Total Polyphenols: the evolution of this parameter appeared to be similar to that of the proanthocyanidins (faster extraction of the set of polyphenols in TT and MDNV tests up until the end of the alcoholic fermentation). From racking to aging, however, the highest values of total polyphenols were found in the TNV and MFNV tests.

Total flavonoids: since this parameter represents the total contributions of anthocyanins and flavanols pigments (the most important polyphenols of the wines with regard to quantity), it seems reasonable that its evolution is similar to that of the total polyphenols.

Color intensity (E420 + E520 + E620): from the end of alcoholic fermentation to aging, as observed for total polyphenols and for total anthocyanins to which this parameter is associated, the values of the color intensity of the TNV and MFNV tests were higher than those of the TT and MDNV.

Shade (E420/E520): the shade values of the four tests, resulting similar at racking, underwent a different evolution after the MLF (shades of TT and MFNV higher than TNV and MDNV). This result may indicate that in TT and MFNV a greater amount of brown polymers formed, making it seem the most advanced color, despite the readings were still typical of young wines from Sangiovese, and taking into account their composition in anthocyanins and flavanols.

Fermentation esters: their content (consisting of fruity aroma) peaked at the end of the FA. The production of these compounds by yeasts was initially faster in the TT and MFNV tests while it was created in the second phase of the FA in the TNV and MDMV tests, which also presented the highest values for those esters in the aging phase of the wines. In this class of compounds, the most represented, as expected, the results are isoamyl-acetate and ethyl octanoate. The contents of each of the fermentation esters and their evolution from the end of FA to aging were in line with what is normally found in red wines.

General considerations

The Banfi Horizon vat, both based on analytical data as well as the sensory evaluation, demonstrated that it could lead to an enhanced expression of color and scents of Sangiovese.

Among the adopted alternative vinification techniques, the best results were obtained from cold maceration, as demonstrated also analytically by the tests carried out in the months after vinification. The wine had a higher content in the glycosylated aromas, especially at a level of norisoprenoids to indicate a slower development of the scents, and a polyphenolic case in line with what was found in the wine obtained in accordance with the traditionally followed fermentation method, but applied to the new fermentor.

4

Corporate sustainability

In 2016, Banfi published its first sustainability report that examines all major aspects related to the Company's impact on the territories in which it operates. In particular, strategies to make these relations more harmonious are identified.
The company is deeply integrated in the natural environment and in the social context. For this reason, it represents a development opportunity for the entire area bringing a surge of technology and innovation in all aspects of agricultural and winemaking management.

4.1 The reduction of the Carbon Footprint

To provide a small, but tangible contribution to the greenhouse effect, agriculture has a formidable weapon, namely the planting of new trees and upkeep of forests. Wood, in fact, is made up of over 50% of carbon 50% and is an important reserve pool to balance the amount of CO2 in the atmosphere sustainably. Banfi has a ratio between forests and cultivated area equal to 1.5:1 that is one of the highest in the European wine industry. In addition, over time the Estate has planted many kilometers of cypress trees, 10 hectares of cork oaks and oaks inoculated with spores for the production of truffles, as well as new forests, which currently reach a total area of 900 ha.
Over the years, Banfi has distinguished itself for the significant reduction in the consumption of diesel, linked to agricultural activities and the management of the various phases of the winery, with a progressive shift towards the consumption of electricity, which is now entirely purchased from renewable sources, with a 15% reduction in CO2 emissions. In particular, this contributed to energy improvement, and thus the reduction of emissions, the modernization and automation of the water treatment plant and the refrigeration system for the winery. These interventions have led to overall benefits both in resource management and energy efficiency, with a reduction of 0.035 MJ/bottle produced. Regarding the bottles, in order to reduce the Carbon Footprint from the producer to the consumer through the entire logistics network ultimately, the use of Bordeaux bottles in lighter glass (360 g instead of 570 g), with a reduction of CO2 emissions of 459 g/bottle and a savings of more than 200 g/bottle in terms of raw materials must be mentioned.
Banfi is also very careful when purchasing cardboard packaging materials, favoring suppliers that produce with a high percentage of recycled material, attested by certifications attached to the products sold. Considering that while 15 trees, 440,000 liters of water and 7,600 kWh of electricity are needed to produce one ton of virgin paper, to produce one ton of recycled paper all that is needed are 1,800 liters of water and 2,700 kWh of electricity and, above all, not a single tree is cut down, maintaining Carbon stocks. Banfi's purchasing policy contributes significantly to environmental sustainability. The Company is also very careful with regard to the packaging line they use. For example, approximately 90% of the capsules are in polylaminate.

4.2 Erosion control

The entire province of Siena has always been considered an area of high risk of erosion due to the topography, geo-pedological characteristics of its soil and the high seasonality of rainfall. The presence of impressive erosive formations, the so-called ravines, characterize, for example, also the landscape of Banfi, along the road from the offices at Casanova to the Castle of Poggio alle Mura. The Company is strongly committed to the containment of erosion in order to deal with a factor that has always been known for its negative impact on the environment along with defending the vineyards located in the hills. Precisely for this reason it has created:
- over 150 km of ditches for water regulation
- 80 km of underground drainage systems
- 10 km of dry stone walls or containing embankments

In addition, it usually resorts to programmed green cover of the vineyards, especially in the sites located on slopes or otherwise subject to land erosion (loamy soils). In this case, the intervention is carried out with specially developed seeders that lay the seeds in soil that has not been processed.

4.3 Water consumption

Against a withdrawal of water from wells on the estate and substantially constant purchases from the water services supplier (respectively, 110,000 and 11,000 m3/year, average values) overall for Banfi Società Agricola and Banfi Srl, Banfi Società Agricola showed a marked annual variability of water extraction from lakes and rivers, related to the course of the production season, especially to the evapotranspiration from the crops, total rainfall and distribution of rainfall during the year. The withdrawals unlikely reach half of the potential reservoir capacity even in the hottest and driest years. However, it should be noted that in the sunniest hours the winds in the area can determine a high evaporation from the water reservoirs: up to 5-7 mm/day, which reduces the available volume.
From January 2016, a project to reuse water and a modification of the wa-

ter treatment system in order to optimize the environmental impact began. Consequently, there is an ongoing time schedule of the interventions for the optimization of the water cycle, which began to show the first results already at the end of 2016. The aims of these actions are essentially:
• reduce the use of chemicals for water softening (particularly, sodium chloride) passing to the reverse osmosis systems;
• reduce the withdrawal of groundwater by increasing the water discharged below the secondary water treatment facility for technological applications (evaporation towers, fire tanks, etc.) and irrigation. This will be possible due to an MBR ultrafiltration system and reverse osmosis.

4.4 Waste management

The Company is committed to recycling activities in every phase of its business: agriculture, offices, winery, restaurants, wine bar and resort.
Banfi also manages the disposal of used oils and the packaging materials of fertilizers and agrochemicals in strict compliance with applicable regulations. The amount of hazardous waste, disposed of by specialized companies, will possibly experience an important increase in a few years due to the intense cycles of uprooting and replanting of vineyards, with the replacement of concrete poles with metal and chestnut wood poles.

4.5 Biodiversity

As already mentioned, Banfi boasts one of the highest ratios between forests and cultivated areas within the estate. To maintain this asset, local varieties have been planted, estate forests have been preserved and managed and areas where water can be drawn for fire prevention have been provided as well as wildlife watering holes.
In many cases, the rich presence of wildlife requires the provision of protection systems for the vegetation and for the crops, such as: vertical mulches (shelter) on vines and plum trees, but also various types of deterrence systems (sound, electrical, scaring) present on other crops.
In the area of Collupino, the Estate breeds a small herd of Amiata donkeys, a special local breed characterized by the presence of a dark cross on the back.
In terms of flora, next to the different crops (plum, cherry, olive, durum wheat, spelt, legumes), Banfi has over 120 wild grass species, which can be found in different seasons of the year. It is interesting to note that this vegetation, because of its complexity, is not very aggressive towards the vines.
There are some species that are now rare or nearly extinct in conventional agro-ecosystems, that it is a real reservoir of flora biodiversity. In addition, during the winter a few species, especially oat grass, protect the soil from erosion. In conclusion, the agronomic management of Banfi's agro-ecosystem vineyard is proof of an optimal balance between economic and ecological sustainability of the territory.

Table 4.1 **- The wildlife-hunting preserve**

The seamless integration with the natural environment is an aspect that strikes everyone visiting Banfi. The presence of a rich and diverse natural wildlife, especially wild boar, pheasant and deer, is supported by the pasture that is provided for them in the Mediterranean vegetation and in the Estate's natural and planted fields. The wildlife management plans are implemented according to the decrees of the Region. In particular, an optimal number of wild animals in relation to the extension and characteristics of the natural environment is attempted to be maintained by implementing targeted culling and capture plans along with the transfer to other wildlife areas.
As part of Banfi there has always been wildlife and hunting preserve, which over the years has grown in extent, from 630 ha in 2013 to the current 842 ha. The main species are ungulates, pheasants, hares and migrators. Within this area, Banfi plants a series of lost crops every year, both during autumn-winter and spring-summer, in order to provide shelter and pasture to the different species.

4.6 Environmental protection

Banfi has always stood for socially responsible management and for the inclusion of innovative techniques and respect for the environment. Since the early 1990s, the company has promoted environmentally friendly cultivation programs, due to a careful control of fertilizers and agrochemical treatments, which have provided a significant reduction of the total amount, due to localization interventions along the row or otherwise strictly targeted to the plant, and the use of environmentally non-aggressive active ingredients. With traceability and the adoption of "integrated pest management protocols", which foresee the complementarity between agricultural operations and treatments, the dual objective of reducing the residues of pesticides producing agricultural products is obtained, limiting the environmental impact at the same time. The agronomists determine when the intervention threshold is reached based on careful and intensive scouting within the plots in order to monitor pests and weeds, with the help of meteorological survey data and the capture of pheromone traps placed in the vineyards, olive groves and orchards.

***Table 4.2* - Contribution to the variety of the landscape: the estate's other crops**

In addition to the vineyards, which are the main crop, over the years the estate has developed further agricultural production activities, designated to enhance the areas distinguished by agronomic characteristics and very diverse production potential, maintaining the varied hallmark of the typical Tuscan landscape.
The estates's second arboreal cultivation, by extension, is the plum orchard (75 ha), for the production of the Agen plum, of which Banfi is the largest Italian producer. Drying and careful calibration take place at the company's Fruit Center. Then, the product is sent to Modena, to a cooperative packaging center. At a nutritional level, plums grown in the vallies along the Orcia and Ombrone rivers are particularly rich in polyphenols, certainly due to favorable climatic conditions that accompany the fruit ripening phase. In Banfi's dried plums, in particular, the content of hydroxycinnamic acids is about three times the average amount found in fruit from other Italian areas.
A selection of the best plums is distilled to produce Plum Brandy. Intense and delicate, it has a harmonious, captivating and sweet scent of ripe prune.
The olive grove (39 ha) is made up for approximately 50% of individual plants or rows associated to the vineyard, as in Tuscan tradition. Besides a small grove of historical plants, recently "restored" thanks to the intervention of expert "artisans" who removed rotting wood, carried out disinfection and consolidation of old wood, even the most recent systems, in "vaso " system have taken on a more environmental significance. The products are used in the estate's hotel and restaurants and the rest is marketed.
The Quercus spp. groves (11 ha), inoculated with the spores of Tuber melanosporum (black truffle), planted in 1984, provide a valuable product to the estate's restaurants and other local restaurants. The truffles, which are collected from October to December, vary according to the climate in the summer; however, in recent years, they have increased, both in quantity and in quality.
The Cherry grove (9 ha), thanks to the presence of varieties which ripen of over a period of about 40 days, is totally destined for the consumer market. The main features of the Banfi cherry are size, color, aroma and long shelf-life, related to varietal selections, to favorable ecological condition of product ripening and careful plant nutrition.
Of the 356 hectares of field crops, all organically grown, there is Senatore Cappelli durum wheat (started in 2016 with 10 ha) and spelt (50 ha total of Triticum monococcum and Triticum turgidum ssp dicoccum), while the rest of the area consists of polyphite meadows.
The estate also intends to add pasta to the production, to be served in the restaurants and also sold in the wine shop.

4.7 The enhancement and development of the territory

Banfi is committed daily in the development of initiatives dedicated to the enhancement of the territory, by participating in events and fairs for the promotion of the estate products and actively taking part in events organized by the Consortium of Brunello di Montalcino. Some activities are directly organized, such as "Jazz & Wine" and the documentary film, by two authors of Montalcino, which narrates and illustrates the area where the estate is located in a fairytale. Other initiatives, such as sponsorships, originate from the requests of the local community, which considers Banfi a great resource for the development of the area. In addition to the above, the company also supports local sports associations, bicycle races including the Eroica, hosts the vintage car rally and, above all, makes annual contributions to the Misericordia di Montalcino for emergency medical services.
The restoration of the Castle of Poggio alle Mura, located 16 km from the town of Montalcino, began in 1983 and enabled to restore an important showcase of the territory's history. Ever since the Etruscan and Roman times and then the Middle Ages, this area, strategically located between Siena and the Maremma, has been contended among various noble families. Today the castle, restored to its ancient splendor, is home to the Villa Banfi Foundation, established in 1986 for the development of activities in favor of the territory and the local community, including the Museum of Glass and Bottles, dedicated to Giovanni Mariani, showcasing the largest private collection of glass in Italy. After the discovery in the estate vineyards of a whale fossil in 2007, the Banfi Foundation has become a promoter of excavation, deposit and, in the future, restoration of archaeological artefacts.

Table 4.3 **- Tourism and food service**

Banfi has always strongly believed in hospitality.
For this reason, the Winery was designed and built to welcome visitors, and open its doors to quality wine aficionados visiting the beautiful countryside of southern Tuscany.
The historic Castle of Poggio alle Mura has been meticulously restored, to become an outstanding center offering a comprehensive and well-structured hospitality.
Located inside a building separate from the main complex of the castle, in what once was a wine cellar, built during the Medieval Ages and repeatedly expanded over the centuries, the Wine Shop recreates the atmosphere of a real Tuscan shop. Here, in addition to the tasting of all Banfi wines, there are many gourmet products and local handicrafts.
In an ideal location, adjacent to the Wine Shop there is Taverna Banfi. Located under the arches of the Castle's ancient wine cellars, where the large barrels used for the aging of Brunello di Montalcino once rested, it offers an exquisitely pleasing ambiance. The kitchen serves the typical dishes of Montalcino and of the Tuscan tradition, enhanced by the freshness and authenticity of the ingredients of the territory.
Another restaurant awaits guests visiting Castello Banfi: the Sala dei Grappoli. Situated in the shade of the historical Castle and in an elegant and refined setting, it serves Italian and Mediterranean dishes, presented with a modern touch. In summer, weather permitting, guests may dine outside on the terrace, while admiring the enchanting view of the fascinating castle.
In the ancient stone village, built in the 18th century, beneath the walls and towers of the Castle of Poggio alle Mura to accommodate the farmers working for the noble landowners, luxury rooms and suites have been created as part of this jewel of extraordinary Italian hospitality. Castello Banfi - Il Borgo offers a refined and exclusive opportunity to relax in the Tuscan countryside, in one of the most impressive and best preserved historical sites of the area. On the outside, the old Tuscan architecture, unchanged over the centuries, is still intact, while the interior has been carefully restored and enriched with all modern comforts. Il Borgo offers the pleasure of discovering and experiencing the most authentic part of Tuscany. Rest and silence, peace and serenity of the Tuscan countryside are enhanced by the dominating view, from an extraordinary location, of the bucolic Brunello vineyards.
Banfi and culture form a strong union, which is developed in many aspects. The Museum of Wine and Glass is part of this cultural context, which occupies several rooms of the Castle. Here, visitors can admire the largest private collection of glass from the Imperial Roman era along with rare objects from past centuries to modern times.


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4.8 Human resources

The Company has always invested in its human resources, to enhance the territory of origin employing young adults offering them a professional and educational career path, which contributed to developing a high sense of belonging to the Banfi community.
In the last three years, there has been an increase in open-ended contracts with a clear advantage of female employees in Banfi Società Agricola S.r.l. and substantial gender equality in Banfi S.r.l. The age segment most involved were 30-50 years and under 30 years. The turnover rate mainly concerns the age group over fifty, as the main cause is retirement, confirming the strong link with the Company.
With training, both mandatory and optional, Banfi invests in safety in all phases of the agricultural and winery activities: from the use of machines and equipment, to the proper management of technical tools to the compliance with waste disposal regulations.

4.9 Certifications and participation in Consortiums for brand protection

Banfi initiated the path towards the adoption of total sustainability criteria obtaining two certifications of its Management systems, directed at quality and environment. This decision involves the entire business process, guaranteeing high quality standards and mandates a vision aimed at continuous improvement.
In December 2005, the SA8000, ethical certification, for company responsibility was established. Banfi is one of a few hundred companies in the world certified with this standard, and it is the first in its industry, guaranteeing its supply chain, from the vineyard to the winery.
At a distribution level, Banfi holds the AEOS Certificate (Security), to benefit from concessions with regards to customs security checks for incoming and outgoing transactions of goods from the customs territory, and the AEOF Certificate (Full), which integrates the control of security aspects allowing the company to also benefit from simplifications provided for in customs regulations.
Lastly, Banfi has the certifications regarding the IFS and BRC international standards, which are international schemes, promoted with the aim of harmonizing the different standards adopted by the major European retail organizations. Both foresee certification audits by Third Party Organizations.
The company participates and is a member of various associations for the protection of trademarks, of which certainly the Consortium of Brunello is the most important, given the close ties with its flagship product.

Looking ahead to the FUTURE

At the end of this report, we deem it necessary to relay a message directed at the FUTURE.
For us, the increasingly globalized world represents an ongoing and stimulating challenge. Together with its employees, Banfi is committed to looking forward in order to timely interpret the ever changing tastes and expectations of consumers. The Company has wonderful natural resources, which its wants to enhance in an absolute sustainable logic.
The commitment we feel we can make is to optimally manage our capital of history and experience, in order to adopt the most suitable technologies to provide Banfi products with full compliance to our "terroirs" in a market logic that will be increasingly demanding and complex.
We gladly accept this challenge, knowing that our customers come first and that the Banfi mission is to satisfy them, in respect of human, environmental and technological resources.

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